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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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The GAS COMMITTEE of the ST. HELENS CORPORATION are prepared to receive

Tenders to Purchase about

170 large SAND STONES, lying at their Pocket Nook Yard, where they can be seen by arrangement.

The Stones, which are suitable for heavy foundation work, engine beds, etc., are of various sizes, some measuring 5 ft. by 3 ft. 6 in. by 1 ft. 9 in.; 6 ft. by 6 ft. by 1 ft. 9 in.; 6 ft. 6 in. by 3 ft. 6 in. by 2 ft.

Tenders are to be sent to the ENGINEER, Gas Works, Warrington Old Road, St. Helens, who will supply any further information required, upon application. X 995

CORPORATION OF CALCUTTA.

NOTICE TO CONTRACTORS.

The Time for the Submission

of Tenders for the Supply, Erection and Installation of an Aerial Ropeway for the Removal of the City Refuse has been EXTENDED from 30th April, 1923, to 1st June, 1923. Tenders must reach the Deputy Chairman, Corporation of Calcutta, 5, Corporation Street, on or before Two p.m. on Friday, the 1st June, 1923, instead of Monday, the 30th April, 1923, as previously advertised.

JAMES R. COATS, B.Sc., M.I.C.E., Chief Engineer.

Central Municipal Office.
20th February, 1923. X 869

MALTA.

Tenders are Invited for

the PURCHASE or LEASE of the DOCK, BUILDINGS, FITTINGS & MACHINERY, situated at Misida Creek, Malta, consisting of Hydraulic Lifting Dock, complete with pontoons and gear, necessary workshops, offices, etc., on shore, the whole to be disposed of as a Going Concern.

Particulars can be obtained from the Rear-Admiral, H.M. Dockyard, Malta, and the Civil Engineer-in-Chief, Admiralty.

All offers are to be delivered to the CIVIL ENGINEER-IN-CHIEF, ADMIRALTY, on or before 1st day of June, 1923. X 959

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of

the following STORES, namely:—

Fee for Specification.

4-WHEELED OPEN GOODS WAGONS. £1

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for 4-Wheeled Open Goods Wagons," not later than Eleven o'clock a.m., on Tuesday, the 10th April, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London,
21st March, 1923. X 997

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

Tenders for Three New

"LANCASHIRE" BOILERS (with fittings) for Abbey Mills Pumping Station, Abbey Lane, Stratford, London, E. 15, each Boiler to be 30 ft. long by 8 ft. diameter.

Persons desiring to Tender may obtain on and after Monday, 26th March, 1923, the Drawings, Specification, Form of Tender, etc., on application to the Chief Engineer at the Old County Hall, Spring Gardens, S.W. 1, upon payment of the sum of £3. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the Drawings, Specification and other contract documents may be inspected at the Old County Hall before payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after Four p.m. on Monday, 23rd April, 1923, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, X 991
Clerk of the London County Council.

ADMINISTRATIVE COUNTY OF LONDON.

The London County Council invites

Quotations for the Purchase

and REMOVAL of FIVE LANCASHIRE BOILERS, each 22 ft. long by 6 ft. diameter, together with Fittings, Pipes, etc.

The Boilers, etc., may be inspected at the Council's Northern Outfall Works, by Beckton Gasworks, East Ham, E. 6.

Forms for Quotation, Conditions of Sale, and full particulars may be obtained on application to The Chief Engineer, at the Old County Hall, Spring Gardens, S.W. 1.

Quotations must be addressed to the Clerk of the Council and must be delivered at The County Hall, Westminster Bridge, S.E. 1., not later than Four p.m. on Monday, 9th April, 1923. No Quotation received after this time will be considered.

The Council does not bind itself to accept any quotation.

JAMES BIRD,
Clerk of the London County Council.
X 990

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BUILDINGS and its PATENTS

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I. Factories for the Manufacturing of Sulphate of Ammonium and Sulphuric Acid, with site of about 70,000 square metres, about 20 kilometres from Gothenburg.

II. Methods of Producing Combinations of Nitrogen, viz.: the production of nitrogen, the purifying of the reaction mixture, catalyzing by means of iron, agglomeration of the reaction mixture, plant for electrical furnace for azotizing, production of oxalic acid and hydrogen.

For the most of these methods have patents been granted or applied for in Sweden, United Kingdom, France, United States, Germany, Italy, Switzerland, Norway and Finland.

The patents include the method known as "the Thorssell method for the chemical production of nitrogen products" (*vide* Tekniska Samfundets i Goteborg handlingar, lecture, Nr. 1, 1920 and "Zeitschrift fur angewandte Chemie," Jahrgang 33, No. 80, 82 u, 84 vom 5, 12 u, 19 Oktober, 1920).

Offers for the real estate, the method or part thereof or the right to exploit it in any particular country are received until the 15th of April, 1923, of the undersigned who also answers all enquiries.

Gothenburg,
the 19th February, 1923.

TORSTEN SETTERBERG,
Solicitor.

V. Hamngatan 10,
Gothenburg,
Sweden. X 898

TO ENGINEERS AND SHIPBUILDERS.

THE CONSERVATORS OF THE RIVER THAMES invite

Tenders for the Construction

and DELIVERY afloat in the Thames at TEDDINGTON LOCK, MIDDLESEX, of a STEEL SINGLE SCREW (or alternatively twin-screw) STEAM RIVER TUG of the following overall dimensions for use on the upper Thames above Teddington:—

Extreme dimensions, 58 ft. by 13 ft. 6 in. by 6 ft. 3 in.
Draft, limited to 4 ft. 6 in. aft, and 4 ft. forward in working trim.
Frames, 2½ in. by 2½ in. by ⅜ in., spaced 14 in./18in. apart with reverse frames, 2 in. by 2 in. by ¼ in., plating ⅜ in. and ⅜ in., plate keel doubled.
Bulwarks of ⅜ in. plate, 18 in. high to tumble in.
Decks, ⅛ in. Chequered plate.
Keelson and side keelsons of ample strength.
Engines, Compound (or triple expansion) Surface Condensing, to develop at work at least 150 I.HP.
Boiler, Marine 8 ft. by 8 ft., 150 w.p. to pass Board of Trade Special Survey.
Trimming Tanks, fore and aft, and pump for filling and emptying.
Propeller. Cast Steel, 4 ft. 6 in. diameter if single screw.
All top hamper to pass under headway of 8 ft. 6 in. above water line, funnel to be made to lower.
The whole to be of first-class British workmanship and British materials, complete with one cabin, storehouse and usual equipment and at least equal in all respects to Board of Trade and Lloyds regulations.
Earliest date when delivery can be effected should be stated.

All enquiries should be addressed to the CHIEF ENGINEER at the undermentioned address.

Sealed Tenders marked "TENDER FOR TUG," accompanied by drawings and full specifications, and addressed to the Conservators of the River Thames, 2/3, Norfolk Street, Strand, London, W.C. 2, must be delivered not later than Ten a.m., on Monday, 23rd April, 1923. No Tender after that time will be considered.

The Conservators do not bind themselves to accept the lowest or any Tender.

F. W. GHARY, Secretary.

Thames Conservancy Offices,
2/3, Norfolk Street,
Strand, London, W.C. 2.
20th March, 1923. X 983

APPOINTMENTS OPEN.

UNIVERSITY OF LONDON.

The Senate invite

Applications for the Ramsay

Memorial CHAIR of CHEMICAL ENGINEERING tenable at University College.—Full particulars may be obtained from the ACADEMIC REGISTRAR, University of London, South Kensington, London, S.W.7. X173

CAPE TECHNICAL COLLEGE, CAPE TOWN.

Applications are Invited for

the following POST.

LECTURER IN MECHANICAL ENGINEERING, Salary £400—25—600.

Applications, which will be received up to the 31st March, 1923, must be accompanied by certified copies of testimonials of training and teaching experience and should state age of applicant. Holders of such posts may be required to join the Government Provident Scheme. Two year's probation, subject to six month's notice on either side, afterwards, three month's notice. £50 allowed for travelling expenses but a proportionate amount of this to be repaid if the contract is terminated in less than two years. Long leave after six years, three months on full, three months on half salary. Applications to be sent to Messrs. CHALMERS, GUTHRIE & CO., LTD., 9, Idol Lane, London, E.C. 3. X 895

Applications are Wanted for

the POSITION of GENERAL MANAGER of Associated British Machine Tool Makers Ltd.—Apply, by letter, giving full particulars of qualifications, salary required, etc., to THE CHAIRMAN, 17, Grosvenor Gardens, London, S.W.1. X 909

Manager Required for En-

gineering Works making Standardised Gas Works Plant and Equipment. Must be good organiser and disciplinarian. Not over 40. State age, salary required, where previous experience gained, and when ready to commence. Acquaintance with mass production methods an advantage.—Address, X 970, Offices of ENGINEERING.

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Require the Services of:—

DISTRICT TRAFFIC MANAGER, of good education, with experience in Traffic Department British Railway. Age 23 to 30. Single. Commencing salary £E.480 per annum.

DISTRICT LOCOMOTIVE SUPERINTENDENT, of good education, trained in Locomotive Works or on British Railway, having A.M.I.C.E. degree or equivalent. Commencing salary £E.480 per annum.

Progressive posts if retained after first contract.—Apply, by letter, giving particulars of education, training, age, etc., to

CONSULTING MECHANICAL ENGINEER,
Sudan Government Railways and Steamers,
5, Northumberland Avenue, W.C. 2.
X 977

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Four Fully Qualified Clerks

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Particulars of the appointments and also full details as to the benefits enjoyed by Municipal Employees under their Terms of Service, may be obtained from the Council's Agents, and applications in candidates' own handwriting, with full information as to experience, etc., accompanied by copies of at least three recent testimonials, and endorsed "Clerk of Works" on the cover, should be forwarded at the earliest possible moment to:—

Messrs. JOHN POOK & CO.,
Agents for the Municipal Council of Shanghai,
68, Fenchurch Street, E.C. 3. X 809

SOUTH INDIAN RAILWAY COMPANY, LIMITED.

An Assistant Electrical

SUPERINTENDENT is REQUIRED for service in India.

The salary of the appointment, which, in the first instance, will be for three years, commences on date of embarkation for India, and will be within the limits of Rupees 450 and Rupees 800 per month, according to qualifications. The passage to India will be paid by the Company.

Candidates, who should be between the ages of 24 and 33 years, should have received a good general and technical education, followed by a training in large Electrical Manufacturing Works, and have had experience as Resident or Shift Engineer in a Power House Supply, and be well acquainted with A.C. High Tension and D.C. three wire systems. A knowledge of the Electrical driving of Workshops and of train lighting is desirable.

Forms upon which applications must be made, may be obtained on written request to Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, London, S.W. 1, Consulting Engineers to the Company.

A. MUIRHEAD,
Managing Director.
91, Petty France, S.W. 1,
19th March, 1923. X 967

Wanted, Engineer, Expert in

up-to-date wireless, including telephony and direction finding. Well educated, possessing thorough training and extensive experience as Mechanical and Electrical Engineer and in Internal Combustion engines and compressing plants. Draughtsman, used to design of mechanical and structural details. Age 20-31. Permanent pensionable appointment. Base rate for 2/3 years £350, equals £504 with present Civil Service Bonus, rising to base £500, equals £696 with Bonus. Bonus varies with cost of living. Civil Engineering experience not required, and amateur wireless no qualification.—Address, A 6, Offices of ENGINEERING.

Competent Engineer Wanted

by old-established firm to introduce Refrigerator work. Must take full responsibility for designing, etc. Adequate assistance provided.—Address, stating age, experience and salary required, X 939, Offices of ENGINEERING.

Engineer, with Experience,

REQUIRED for Sisal Plantations in B.E.A. Knowledge of Suction Gas and Steam Engines, Decorticators, etc. Preference to one having previous experience and knowledge of country, single, age about 35. Good prospects for capable energetic man.—Write, stating salary required, with copies of three recent testimonials, BOX 226, DORLAND AGENCY, Ltd., 16, Regent St., S.W. X 947

Wanted.—Experienced

Chemical Works ENGINEER REQUIRED for a large Chemical Factory in the Midlands. Thoroughly acquainted with the design, construction and operation of all classes of chemical plant. Particulars of scientific training, with details of experience, copies of testimonials, salary required. —Address, X 971, Offices of ENGINEERING.

Wanted.—Several Engineer-

ing GRADUATES—preferably with an Engineering Degree—REQUIRED for training as Sectional Engineers in a large Chemical Factory in the Midlands. Good prospects for men with scientific knowledge, initiative and energy.—Address, X 972, Offices of ENGINEERING.

Sales Engineer for Contrac-

tor's Plant. Wanted for India. Must have first-class education, combined with selling ability, and preferably able to prepare, unassisted, layouts of concrete mixing and distributing plant, also supervise erection and running. Salary £400/£600 plus travelling expenses plus bonus on profits with reasonable increase of salary yearly. Period three or five years. Must be of good social standing and able to negotiate big business. Age 25 to 30. Unmarried. State full particulars of education and experience. Will be required to undergo training at our Works before proceeding overseas about August.—Address, X 961, Offices of ENGINEERING.

H.M. SIGNAL SCHOOL, R.N. BARRACKS, PORTSMOUTH.

Applications are Invited

for TWO VACANCIES for ENGINEERS, Grade II., in the Laboratory Section of the above School. The duties concern the development of Wireless Telegraphy, etc., for Naval purposes. Preference given to candidates possessing an Honours Degree in Physics or Electrical Engineering.

The salary scale is £150, rising by annual increments of £10 to £300 per annum, plus bonus based on the average cost of living figure. The minimum pay plus bonus at present is £244 per annum.

The appointments are not established and the Federated Universities Superannuation Scheme is applicable.

Applications, giving full particulars of the candidate's experience, War Service, etc., should be addressed to "THE SECRETARY OF THE ADMIRALTY (C.E.), Admiralty, S.W.1," from whom further particulars of the duties, etc., can be obtained. X 902

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Salary, Taels 400 per mensem, under a three years' agreement, which is renewable at a higher salary in the event of satisfactory services. First class passage is granted, with half pay during voyage. Free medical attendance is provided, and the Employee participates in the benefits of a Superannuation Fund. A Tael at the present rate of exchange equals 3s. 1d., exchange is, however, subject to fluctuation.

Taels 400 per mensem, at exchange 3s. 1d., is equivalent to about £740 per annum.

Particulars of the appointment, and also full details as to the benefits enjoyed by Municipal Employees under their terms of Service, may be obtained from the Council's Agents, and applications in candidates own handwriting, with full information as to experience, etc., accompanied by copies of at least three recent testimonials, and endorsed "Assistant Engineer" on the cover, should be forwarded at the earliest possible moment, to:—

Messrs. JOHN POOK & CO.,
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THE GRAPHICS OF THE SYNCHRONOUS MOTOR.

By W. M. WALLACE, Wh.Sc., A.R.C.S., A.M.I.C.E.

IT is usual to exhibit the peculiarities of the synchronous motor in certain characteristic diagrams. These diagrams show, amongst other things, that for a given field the motive power varies with the angle of advance of the motor e.m.f.; that there are two angles of advance for any given power, at one of these angles, however, the motor is in an unstable condition; that for a given field there is a certain maximum load which must not be exceeded or the motor will be forced out of step with the terminal $p\,d$. It is not easy for a student to follow through the genesis of these diagrams unless he draws them out for himself; a long and tedious process.

The diagram proposed by the writer exhibits all the characteristics of the synchronous motor at a glance and is extremely simple in construction. The simple vector diagram for the synchronous motor is shown in Fig. 1, where O A represents the terminal $p\,d$ and O B the back or motor e.m.f. Then O C the diagonal of the rectangle O A C B will

Fig. 1.

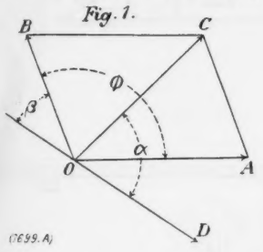


Fig. 2.

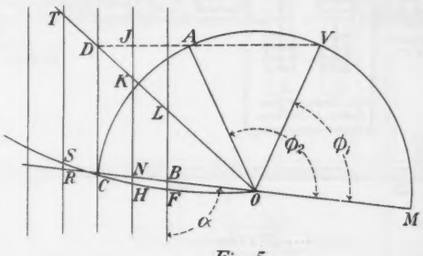


Fig. 3.

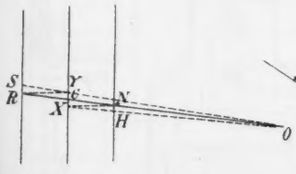


Fig. 4.

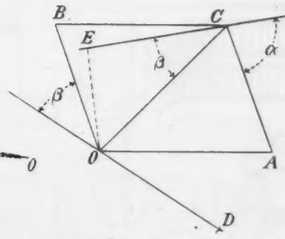
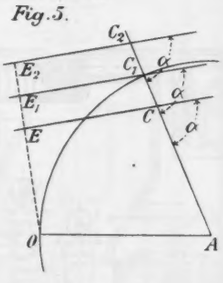


Fig. 5.



show the resultant e.m.f. forcing current through the armature against its reactance and resistance. If O D represents the current vector it will lag behind O C by an angle a whose tangent is approximately $\omega\,L \div r$; ω being the angular velocity corresponding to the frequency, L the armature inductance and r the armature resistance. The angle of advance of the motor e.m.f. is shown by ϕ. The current flowing (i) is proportional to O C ÷ impedance, and the motive power to:

$$\text{O B} \cdot \cos\beta \cdot i = \text{O B} \cdot \cos\beta \cdot \frac{\text{O C}}{\text{impedance}}.$$

It is plain then that to get out curves of current and motive power for various angles of advance and motor e.m.fs. is a long and tedious operation, and for this reason the following construction is proposed. Draw a line C M (Fig. 2) inclined to the vertical at an angle a. With centre O draw a semicircle C A M of radius equal to the terminal $p\,d$ to convenient scale. Draw verticals L F, H K, C D, R T at distances from the centre O proportional to various back e.m.fs. corresponding to various field strengths. Draw the base curve O F H C S—the method will be described later. Corresponding to any angle of advance ϕ_2—or ϕ_1—draw the line V A D horizontal, meeting D C in D. Join D O. Then for any given field, say K H, the current is proportional to the distances N A, N V, respectively, and the motive power to the length of the ordinate intercept K H between the straight line O K and the base curve O H F C S. It is usual to draw a separate diagram showing how, for any given angle of advance, the motive power varies with the strength of the field. This is shown at once here by the various ordinate intercepts F L, H K, C D, &c.

Then diagrams showing the various motive powers as the angle of advance ϕ is varied are unnecessary as our diagram plainly shows them. A vertical through O shows the angle for which maximum motive power is obtainable for every field. Instability on an angle such as ϕ_1 is exhibited by the fact that any increase of load slowing down the motor and reducing ϕ_1 reduces also the power of the motor; reducing ϕ_2 on the other hand obviously increases the power.

Curves are also drawn showing how far various fields of the armature current differ with the angle of advance of the motor e.m.f., but our diagram exhibits these sufficiently well to render the drawing of such curves as superfluous as the other curves. For example, for field strengths corresponding to the verticals through the points B, N, C, R, respectively, the currents for angles of advance ϕ_2 and ϕ_1 are proportional to the distances B A, B V; N A, N V; C A, C V; R A, R V. The actual values of the currents are equal to the lengths of these lines measured on the voltage scale divided by the impedance of the armature.

Construction of Base Curve.—The base curve passes through the points O and C (Figs. 2 and 3). To find point H on N H draw N X horizontal to cut vertical through C in X. Join X O, cutting N H in H, the required point. To find point S on S R, draw R Y horizontal, cutting a vertical through C in Y. Join Y O and produce to cut R S in S.

Proof of Construction.—Referring again to Fig. 1 (the vector parallelogram of which is reproduced in Fig. 4), the motive power is proportional to

$$\text{O B} \cdot \cos\beta \cdot \frac{\text{O C}}{\text{impedance}}$$

that is, to O B, O C cos β.

Draw the line E C G (Fig. 4), making the angle G C A = a, then the angle E C O = β; and, if O E is drawn perpendicular to E C, E C = O C cos β; and the motive power is proportional to A C, E C.

For various field strengths A C, A C_1, A C_2 see (Fig. 5) the corresponding motive powers will be proportional to the products A C. E C; A C_1. E_1 C_1; A C_2. E_2 C_2. Let A C_1 be the motor e.m.f. equal to the terminal $p\,d$, and draw a circular arc through O with A as centre, then intercepts E C, E_1 C_1, &c., may be obtained for various angles of advance by rotating O anti-clockwise around the circle. The angles of advance are, of course, the supplements of such angles as O A C.

To obtain single ordinate-intercepts corresponding to the motive powers it is necessary to reduce or increase E C, E_2 C_2 proportionately to the strengths of the field and the constructions of Figs. 2 and 3 are necessary. Suppose the line J N (Fig. 2) to correspond to the line E C (Fig. 5). This must be reduced in the proportion O N : O C. Now K N : D C :: O N : O C, but J N is slightly longer than D C and the construction of Fig. 3 is necessary to add N H to K N; N H being the requisite proportion of the difference between J N and D C. The actual value of the motive power is, then,

$$\text{K H} \times \frac{\text{terminal p. d.}}{\text{impedance}};$$

K H being measured, of course, on the scale used for the voltage vectors.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

By W. NOBLE TWELVETREES, M.I.Mech.E., A.M.I.E.E., M.Soc.C.E. (France).

(*Continued from page* 294.)

Engine-House Plant.—Under the scheme prepared by Mr. Chattock for the ultimate completion of the new generating station, generators with a normal capacity of 105,000 kw. will be installed. Provision is made for seven 15,000 turbo-alternator sets in all, of which two sets have been erected and are now in operation. In addition to these, the plant at present laid down includes three 350-kw. Peebles motor generators, and condensing plant of the Weir Uniflux type. Provision is now being made for the installation of a third turbo-generator set.

Turbo-Generators and Auxiliaries.—Each of the first two 15,000-kw. turbo-alternator sets, supplied and erected by the British Thomson-Houston Company, Limited, comprises a high-pressure horizontal Curtis turbine, direct-coupled to a 22,500 k.v.a. alternator running at 1,500 r.p.m. generating three-phase, 25-cycle current at 5,250 volts, with a direct-connected exciter of 125-kw. capacity at 220 volts, and having an output of 20 per cent. more than the maximum excitation required for the turbo-generator; a motor generator set for use as a stand-by exciter; temperature detectors and indicators for various part of the plant; a reversible 220-volt direct-current motor for controlling the governor from the switchboard during synchronisation; and a Ferranti type rheostat for the exciter field. The arrangement of the two machines with their various accessories is shown in the side elevation, plan and end elevation given in Figs. 78, 79 and 80, on pages 354 and 355.

Turbines.—Each turbine is of the Curtis combined impulse type, having 17 stages, the first of these with two rotating rows of buckets and the remaining stages one row each. Steam is admitted to the first stage through high-pressure nozzles, consisting of high carbon steel division plates cast in position and set at the proper angle for directing the steam against the buckets, and arranged in sections, each connected to a separate control valve. The valves open successively in accordance with the output, thereby reducing throttling of the steam to a minimum. In subsequent stages, the nozzles occupy the whole of the periphery and consist of division plates cast in the diaphragms. Owing to the high temperature of the steam several nozzle diaphragms are of cast steel, but in the later stages they are of cast-iron. The casing at the high-pressure end is of cast-steel, and at the exhaust end of cast-iron ribbed and stayed. The housings for the turbine and alternator bearings are integral parts of the exhaust end bottom casing, thus ensuring permanently correct alignment. The high-pressure end casing is carried by and bolted to the pedestal of the turbine bearing, this pedestal resting upon the steam end base and being free to move in an axial direction to allow for expansion and contraction of the casings. As the thrust bearing is also carried by this pedestal the correct position of the steam rotor, relative to the casings, is always maintained.

The critical speed of the shaft is 2,000 r.p.m. The shaft is of high grade carbon steel, smooth finished all over, and the journals are polished. The shaft packings at the steam and exhaust ends are of labyrinth type, with provision for inspection or renewal of rings without lifting the upper casings of the turbine. The glands are fitted with guards to prevent the small amount of steam which leaks past the packing from finding its way into adjacent bearings, such escape steam being discharged through vent pipes above the top half casings. The gland piping is fitted with a shaft packing pressure regulator, in order to maintain the pressure in the space inside the outer labyrinth rings slightly above atmosphere. The bearings are spherically seated, self-aligning, and lubricated under pressure from a

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

Fig. 78. ELEVATION ON STEAM END OF TURBINES.

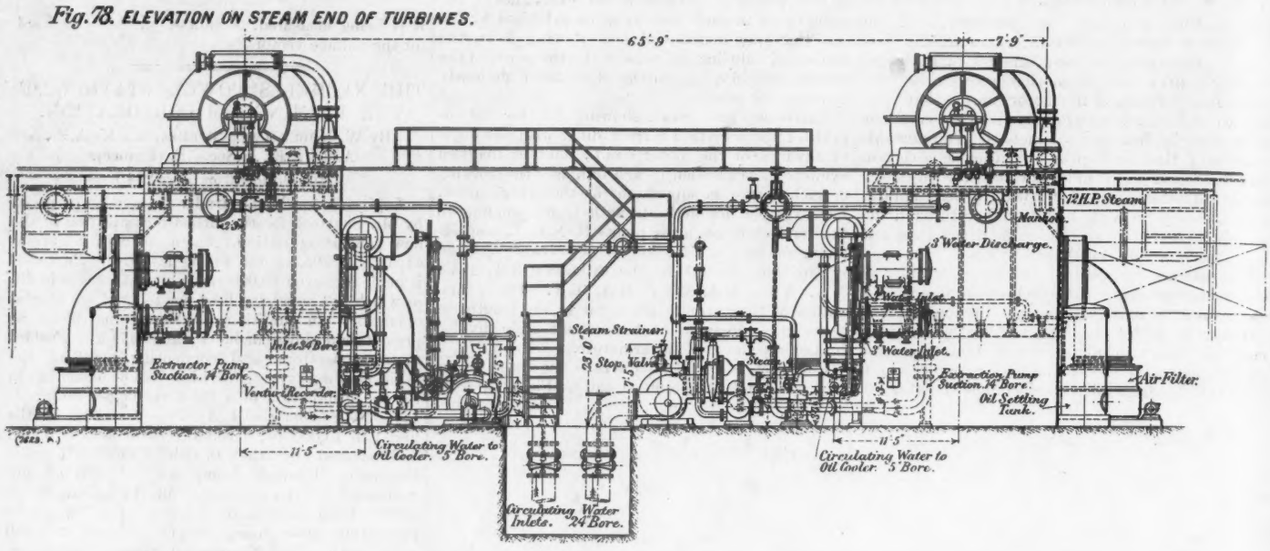
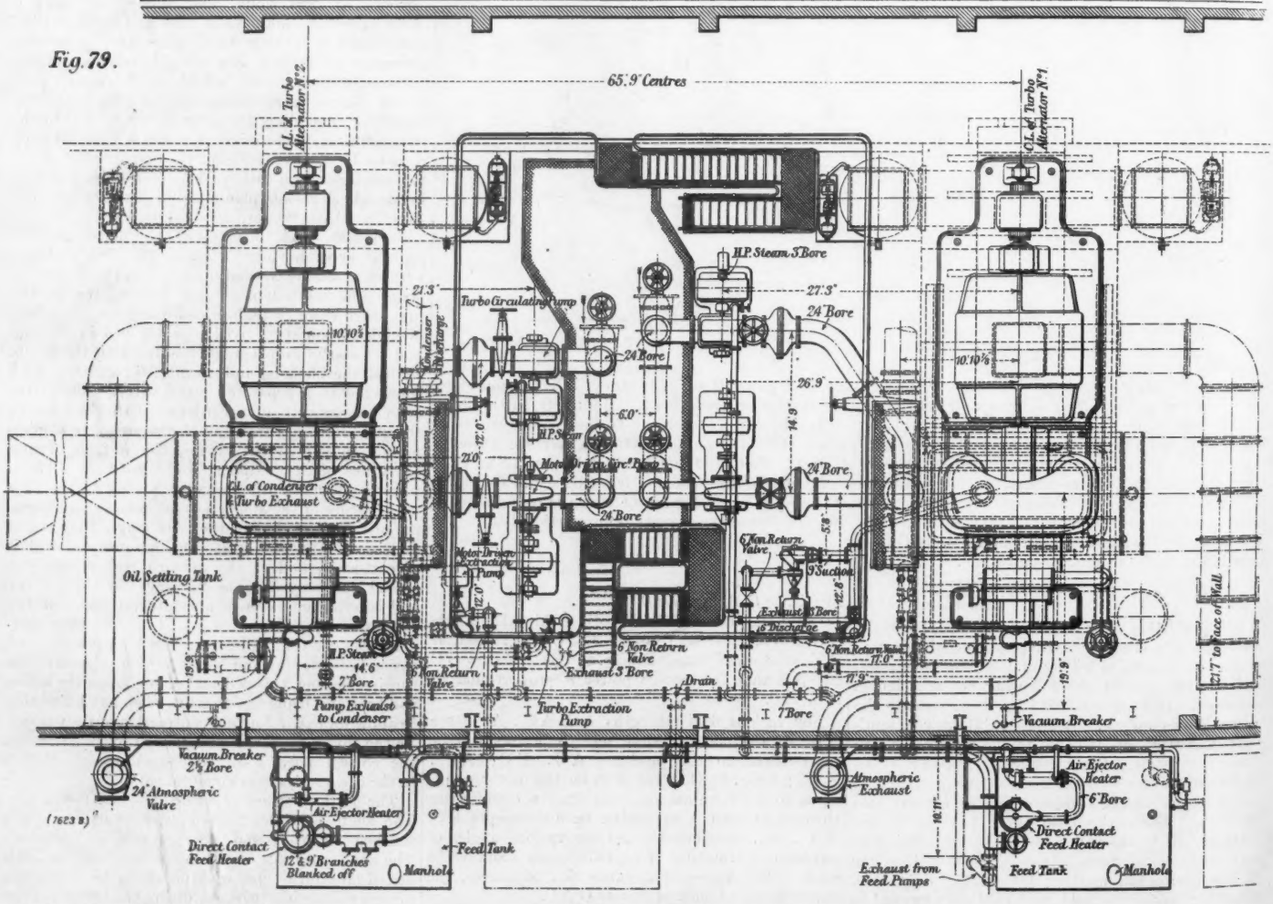


Fig. 79.



valveless rotary oil pump, a separate turbine-driven oil pump acting as a standby and for use when starting and stopping the set. This pump starts automatically if the oil pressure should drop through failure of the main oil pump.

End thrust is taken by a multi-collar type of thrust bearing, capable of axial adjustment by means of worm gear operated outside the pedestal bearing, thus permitting the clearance to be regulated while the turbine is running. The turbine and alternator shafts are connected by a double claw flexible coupling, arranged so that either the turbine or the alternator rotor can be removed without disturbing the other.

The turbine governor carried on an extension of the shaft is driven by worm gear, the governor actuating the controlling valves through an oil relay system, and an emergency governor with combined emergency and stop valve is fitted to cut off steam automatically before a dangerous speed can be attained. Motor-driven synchronising gear is included in the generating set, as well as a system of Cambridge and Paul instruments for the observation of steam, oil and water temperatures.

The normal steam conditions for the turbine are as follows: Pressure per square inch, 300 lb. gauge; superheat, 278 deg. F.; total temperature, 700 deg. F.; vacuum, 28 in.

The approximate weights of the principal parts and the total weight of the turbine are as follow:

THE NECHELLS POWER STATION, BIRMINGHAM.

Fig. 80.

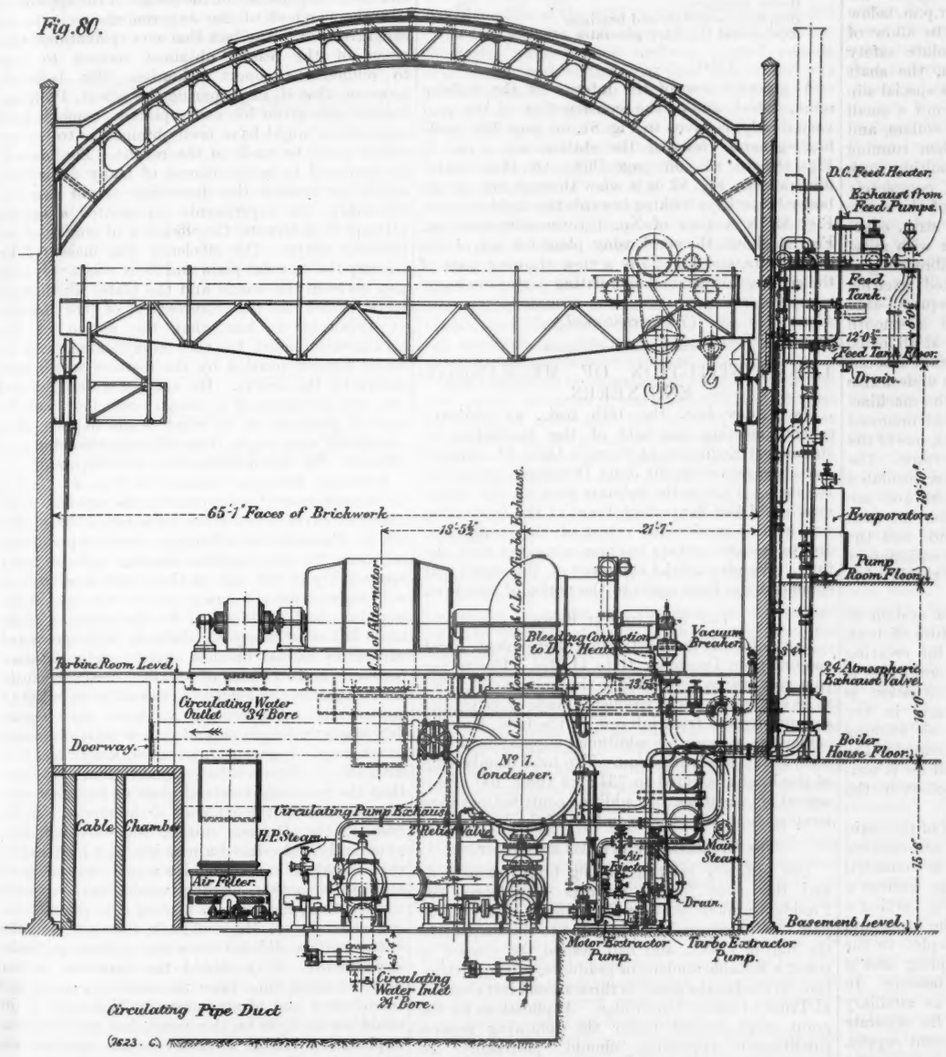


FIG. 81. ROOF OF TURBINE ROOM.

	Tons.
Steam end casings	18
Exhaust end casings	43
Steam rotor	13
Steam end pedestal and base-plate	7
Control valve casing, bearings, covers, valves, pipework, &c.	15
Total weight	96

Alternators.—The alternators are of the totally-enclosed air-cooled type, direct coupled to the turbines and provided with direct-coupled exciters and auxiliary direct-current generators. The construction of the alternator and exciter follows British Thomson-Houston standard practice, which is now so well known that a brief outline description will be quite sufficient.

The stator frame is of cast-iron divided into halves vertically. It is of the box type, the space between the outer and inner shells serving as a passage through which the ventilating air is conducted to the exit duct. The frame is machined on its inner surface to support the laminated iron core, and is provided with all necessary access and inspection openings.

The stator core laminations, of high permeability steel, are coated on both sides with insulating enamel. They are in the form of segments, which are assembled in the frame so as to break joint between successive layers. The complete core is clamped in position between cast-iron end flanges attached to the frame by screws, thus avoiding the use of bolts passing through the punchings. Radial ventilating ducts are provided at frequent intervals, and the teeth of the punchings are supported at the ends by steel fingers attached to the end flanges. As the size and weight of the complete stator were beyond the limits imposed by existing railway facilities, it was necessary to cast the frame in halves for transport and to conduct the operations of assembling the frame and of building up the laminated core on the site.

The stator winding is of the bar type arranged in two layers in open-type slots. The end portions of the windings are carried by bronze rings well insulated and mounted on brackets on the end frames. The conductor, consisting of a large number of separate laminations, is insulated with wrappings of mica tape hot pressed to dimensions and continued throughout the entire length of the coil. The laminations are individually insulated, the insulation being continued without a break through the entire length of the winding from the high voltage terminal to the neutral terminal. In this way losses due to eddy currents are reduced to a very low value. The stator windings are subjected to a high potential test of 12,000 volts for 1 minute, both to earth and between phases before the machine is put into service.

The rotor is of the cylindrical non-salient pole type with distributed windings. The magnetic core is built up of high-tension steel laminations in the form of complete rings, mounted tightly on the steel shaft and firmly held between steel end plates by bolts passing from end to end. The centre portion of the shaft carrying the core is machined with axial passages for ventilating air, and radial air ducts are provided at frequent intervals throughout the length of the core between the

laminations. The slots for the exciting windings are of the open type, with provision for receiving the dovetail keys by which the windings are made secure against centrifugal force. The rotor is designed with its critical speed at 1,000 r.p.m., or 500 r.p.m. below the normal running speed. In order to allow of running through this speed with absolute safety and freedom from excessive vibration, the shaft journal at the exciter end is carried in a special slip bearing. This is arranged so as to permit a small amount of radial play between friction collars, and the radial movement so occurring when running through the critical speed, with the resulting work which is done on the friction collars, completely counteracts any tendency to whipping of the shaft.

The exciting windings are of copper strip, edgewise wound, insulated from one another with mica, and from the core by means of mica and fibre troughs. This type of rotor, having distributed exciting windings and a practically uniform squirrel-cage winding, results in the generation of a smooth potential wave approaching a sine wave at all loads, the squirrel cage winding permits a certain amount of unbalanced single-phase load without undesirable heating effects in the various parts of the machine.

The collector rings are of forged steel mounted with a shrink fit on mica insulated sleeves, one of the latter being mounted at each end of the rotor. The collector brush holders are mounted on insulated rings attached to the outer air shields, and are readily accessible. There are 12 brushes for each collector ring, spaced equally all round, and the contact density is of so low a value that satisfactory operation is ensured should any one of the brushes fail to make perfect contact.

The alternator is constructed with a system of radial air ducts in the magnetic structure of both rotors, shrouded fans being included for creating the necessary draught. The use of external fans is therefore dispensed with. Air for ventilation is drawn into the machine through ducts in the foundations, and is passed through the air washing plant before admission. An outlet is provided at the bottom of the frame, whence the heated air is conveyed through a duct to the steam boilers in the adjoining building.

The Exciter, mounted on an extension of the main bedplate, is a six-pole shunt-wound self-exciting machine, with commutating poles, and is connected directly to the alternator rotor windings without a series rheostat, control being effected by varying a rheostat in the shunt field circuit. The armature, of the slotted drum type is direct coupled to the alternator shaft through a flexible coupling and is fitted with an outboard pedestal bearing. In addition to the main shunt winding an auxiliary shunt winding is provided, arranged for separate excitation from any available direct-current supply. The object of the auxiliary winding is to ensure stability when the alternator is being excited at low loads. Multiple brushes are provided, capable of individual pressure regulation and the exciter operates sparklessly at all loads with fixed brush position.

Auxiliary Direct-Current Generator.—In addition to the exciter, each main generating unit is provided with a 250-kw., 440-volt to 460-volt shunt-wound generator, contained in the same magnet frame and with its armature mounted on the same shaft as the exciter, but otherwise constituting an independent machine. The function of the generator is to supply power for the operation of auxiliary machinery, and the machine is designed to be capable of giving the rated output with a 10 per cent. drop in speed.

Stand-by Exciter Set.—A motor generator set, driven by a 400-volt 25-cycle three-phase protected type induction motor has been provided as a stand-by exciter. The set runs at 485 r.p.m., the exciter generating at 220 volts and giving an output of 20 per cent. above the maximum excitation required for one generator set.

Air Filters for Alternators.—The air filters for the two alternators were made by Messrs. William Grice and Sons, and are of their twin type "Invincible" wet air filters, each twin unit being capable of dealing with 60,000 cub. ft. of air per minute. Each filter is driven by a direct-current 440-volt to 460-volt motor rated at 1¾ h.p. and running at 960 r.p.m.

Approximate Weight of Alternator.—The weight of the alternator is made up as follows :—

	Tons.
Stator, complete	85
Rotor, complete	25
Bedplate, pedestals and bearings ...	20
Exciter and auxiliary generator ...	8
Total	138

A general view of the interior of the turbine room, which shows the construction of the roof very clearly, is given in Fig. 81, on page 355, while four general views of the station are given in Figs. 82 to 85, on page 368. Of these latter illustrations, Fig. 82 is a view through one of the boiler-house bays looking towards the turbine room, Fig. 83 is a view of No. 1 turbo-alternator set, Fig. 84 shows the condensing plant for one of the main units, and Fig. 85 is a view showing part of the cooling towers and circulating water-discharge mains.

(To be continued.)

THE INSTITUTION OF MECHANICAL ENGINEERS.

ON Friday last, the 16th inst., an ordinary general meeting was held of the Institution of Mechanical Engineers, at Storey's Gate, St. James's Park, the president, Sir John Dewrance, occupying the chair. Prior to the ordinary meeting, the annual meeting of the Benevolent Fund of the Institution was held to receive the report of the committee, and to transact certain business connected with the fund. We give a brief summary of the report and commend the fund again to the notice of members.

THE BENEVOLENT FUND.

The total of the Institution Benevolent Fund amounted on December 31 to 11,610*l.* During the past year grants were made to the amount of 1,143*l.*, to 18 applicants. The payments made exceeded the amount derived from interest on the fund, and the committee appeals for additional support from the members of the Institution. The total membership of the fund amounted to 734; of these 100 represented life members. In addition contributions were received from 165 other members of the Institution.

THE WILLIAM HENRY ALLEN GRANT.

The ordinary meeting having been commenced, and the usual formal business despatched, the President announced that Mr. William Henry Allen, past vice-president, had presented to the Institution the sum of 1,000*l.*, and had desired the council to select a suitable student or graduate, of the Institution, to receive the grant in three annual instalments, at Trinity College, Cambridge. Applications for the grant were invited under the following general conditions :—Applicants should preferably be between 20 and 25 years of age, and not in possession of a University degree, but must have such educational qualifications as will ensure that they will derive the maximum possible benefit from an honours course in engineering (mechanical science tripos) at Cambridge. Preference will be given to an applicant who has had some practical workshop training. The applicant to whom the award is made will be required to go into residence at Cambridge in October, 1923, to pass the Cambridge University Previous Examination not later than that date, and to read for the B.A. Degree in Engineering (Honours). Applications should be made on a form to be obtained from the secretary, and must be received at the Institution not later than May 1, 1923.

The President proposed a hearty vote of thanks to Mr. W. H. Allen, the donor, for his generosity. This was seconded by Dr. H. S. Hele-Shaw and warmly supported by members present.

SECOND REPORT OF THE STEAM-NOZZLES RESEARCH COMMITTEE.

The next business was the presentation of the above named report to the meeting. In doing this, Professor G. G. Stoney, F.R.S., summarised the main point brought out by the experiments and the principles guiding the research,

Professor A. L. Mellanby opened the discussion. He feared that there would be a certain amount of disappointment in relation to the report and that those interested in turbine questions would feel that it did not much assist in solving the problems of turbine design. It was, however, undeniable that the experimental work was of a very high order, and those responsible for the design of the apparatus and the conduct of the experiments were to be congratulated. The fact that no explanations were given of the results obtained seemed to him to render the report colourless. He believed, however, that if, in preparing the report, Professor Stoney had given his own opinions, some helpful suggestions might have been obtained as to the use which could be made of the results. For himself, he confessed to consciousness of many difficulties, which he trusted the discussion would remove. Obviously, the experiments represented a careful attempt to determine the efficiency of nozzles of an intricate shape. The efficiency was measured by the impulse on a flat plate and there was a very long gap between the nozzle and the plate, which must have added to the complexity of the results. It appeared to him that the action of the arrangement must be very complicated, and he found himself puzzled by the features which were shown by the results. He was not a designer and was not in search of a design coefficient, but for general guidance as to what would happen when variations were made from the experimental conditions. For this fundamentals were required.

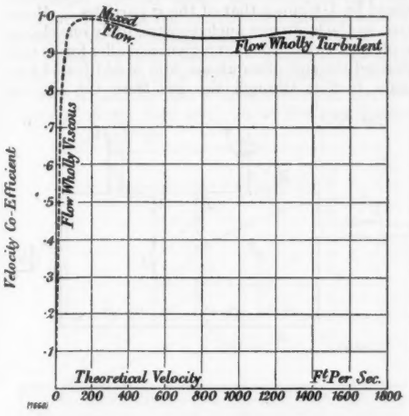
Professor Mellanby referred to Figs. 4 and 5 in the second report,* and pointed to the rapid fall in the efficiency curve between the velocities of 300 ft. and 800 ft. Thereafter the efficiency remained practically constant for the impulse nozzle, but fell away appreciably in the case of the reaction nozzle; at still higher speed it again rose in the case of the impulse nozzle. He asked for the meaning of the rapid fall in efficiency at relatively high speeds and why there should be that characteristic difference between the two forms of nozzle. Again, he would have expected the length of channel to have had an appreciable influence, or at least that regular differences in length should give regular differences in readings. Apparently, however, length had very little effect. The results seemed to him to indicate that the generally received ideas of fluid flow were contradicted by the evidence of the report. In the case of the Parsons nozzle, the curvature had, apparently, introduced a new loss of a higher order than might be expected. He would have imagined that the reaction blading would have a better surface than the impulse blading; in practice this was generally so. He would ask, therefore, why this better surface did not show up in those particular experiments. Why should the curvature at one and the same time raise the critical velocity and introduce a loss of an unusually high order? He could see no light on this point, but he thought an explanation was as essential as the question was legitimate. He would also ask whether, if one general efficiency curve were given for all kinds of tail lengths, would it serve for all kinds and heights of blading? He had endeavoured that morning to impress upon the committee that it was desirable to get down to fundamentals, the best way of doing which was to make some experiments with straight nozzles, so getting rid of the complications occurring at the curved inlet and those which occurred at the oblique outlet.

Mr. H. M. Martin, who spoke next, in the first place asked Professor Mellanby to explain his objection to the gap between the nozzles and the pad. In this space the jet was clear of any fixed solid surface, and there could be no change of momentum in that space. The whole of the momentum of the jet must go on to the pad, whether the space between the nozzle outlets and the pad was 1 in. or a mile.

The discovery of the phenomenon referred to in the report as the "flapping" of the jet was obviously of very great importance, and had a very direct bearing on turbine design. The curves representing the velocity co-efficients showed some peculiarities, but these appeared to be all capable of rational explanation, at any rate of a qualitative kind, and much about what might perhaps have been anticipated from theoretical considerations. He had placed on the wall a diagram in which he had extrapolated curve 4, Fig. 1, of the report to

* We publish both the first and second reports on pages 377 and 380 of the present issue.

zero velocity. This is reproduced in the accompanying diagram. This extrapolation was, of course, merely intended to show the probable run of the curve and did not represent an accurate calculation. At very low velocities the flow must be viscous, and it was known, from theory, that in



viscous flow the limiting value of the velocity co-efficient was zero at zero velocity. As the speed rose from zero this velocity coefficient increased, at first very rapidly and afterwards very slowly, so that, assuming it were possible for the flow to remain viscous, unit efficiency would only be attained at an infinite speed of efflux. Actually, unit efficiency was nearly attained at very low speeds, a fact of which advantage was taken in the use of nozzles for metering air.

The flow of a fluid did not remain viscous. At some definite velocity, depending on the form and proportions of the blading, turbulence would make its appearance near the outlet, and, as the speed was still further increased, would extend further and further into the blading. Since surface friction was higher with the turbulent than with viscous flow, that extension of the turbulence further into the blading offset the gain which would otherwise have resulted from the increase in the velocity. Hence there was for every nozzle some definite velocity at which the efficiency was a maximum, and this was indicated in the diagram. From this point the efficiency fell until the turbulence extended nearly up to the inlet. When he communicated this view to Professor Stoney some months ago, the latter pointed out that were it possible to assimilate the 1-in. Parsons blading to a straight pipe, turbulence should make its appearance at a speed of 92 ft. a second as a maximum. It had, however, to be noted that it was very difficult to produce turbulence in a converging channel, and in fact Osborne Reynolds could not get it to extend into the converging mouth pieces of his pipes. Professor Coker had the same experience with a Venturi meter, as described in a paper read before the Canadian Society of Civil Engineers in 1902. It should, however, be added that whilst Professor Coker found it impossible to start turbulence in the converging section of the meter, he found that if the fluid were already turbulent when it reached the meter this turbulence might be retained in the entrance cone. That point was of importance, as it suggested the possibility that in practice the efficiency of Parsons blading at low speeds might be less than the experiments would indicate, as special pains were, of course, taken in the research to deliver the steam to the nozzles in a steady state. Returning to curve 4, it was well known that in turbulent flow the frictional losses did not in general increase quite so fast as the square of the velocity. Hence, once the flow was turbulent throughout the nozzle an increase in the velocity coefficient might be expected, and such an increase was shown in curve 4, at least at first.

Later on the curve showed a slight decrease in the velocity coefficient. That, he thought, was attributable to the *vena contracta* getting closer and closer to the nozzle outlet. That this did occur seemed to be clearly proved by the discharge co-efficient for the nozzle, which increased somewhat rapidly after a velocity of 800 ft. a second was attained. Rosenhain had shown, many years ago, that the highest velocity coefficient was attained with a sharp-edged orifice, in which, of course, a larger fraction of the final momentum was generated after the jet was well clear of all solid surfaces. Similarly, when a *vena contracta* formed outside of a nozzle, part of the total final momentum was generated with no loss from wall friction. The proportion thus generated would be smaller the closer the *vena contracta* was to the nozzle outlet. It was to an effect of that kind that he was inclined to attribute the slight fall in efficiency shown by the curve at speeds of over 130 ft. per second. He thought also that the shape of the curve obtained with the Parsons blading was in part due to the same phenomenon though he was inclined to conclude that owing to the special shape of the Parsons blading the turbulence might extend into it less rapidly than it did in the case of the impulse blades, and that the character of the flow might not approach complete turbulence throughout until much higher speeds were attained.

With regard to that portion of the curve obtained with speeds in excess of the speed of sound, it must be borne in mind that the jet was in that case delivered from the nozzle at a pressure in excess of that in the discharge box. As a consequence "standing waves" were produced and measurements taken along the axis of the jet would show a pressure alternately higher and lower than the discharge-box pressure. The impulse recorded would therefore depend on whether the position of the pad corresponded to a node or a loop.

Dr. Harvey N. Davis, of Harvard, remarked that the report interested him the more because he had had the pleasure of being in the practical turbine designing business for a year, and the rules of thumb then used, without any justification, were corroborated in many respects by the experiments recorded in the report. His interest in the whole subject of steam was an additional reason for his interest in the paper. Within the last year, there had been instituted in the United States a group of experiments in some ways paralleling and in some ways supplementing the admirable work of Professor Callendar. He had worked on steam in the laboratory for a number of years, and could fully appreciate the difficulties experienced by members of the Nozzles Committee, difficulties which, apparently, they had overcome with marked success, and he desired to congratulate those gentlemen on an admirable piece of work. He suggested the desirability of adopting a standard value for g for use in English-speaking countries. This would make it easier for scattered readers to check, re-compute and re-plot and work over data.

Mr. L. N. Robinson observed that Professor Mellanby had intimated that, in his opinion, the report had not much practical value for those whom the committee hoped to serve. Together with Mr. Chittenden, he, the speaker, had been appointed to represent the turbine builders in the "Beama," and at a recent meeting of the Turbine Research Section of that body, he had been informed by the designers to the largest turbine-builders in the country that they were well satisfied with the work done, although they had not then had the opportunity of getting certain information which had since been placed before them, and which would probably form part of the subject of the Third Report. They had also stated that they hoped arrangements would be made to enable Professor Stoney to continue the work for a considerable time in the future. Professor Mellanby had also suggested that had Professor Stoney been unhampered by the committee he would probably have written a very different report. He had seen the first draft report prepared by Professor Stoney and had been present when the committee read that report through, line by line, making such modifications as they thought necessary. Those modifications were purely of an editorial nature, and it would thus be understood that the report represented Professor Stoney's own personal work, aided by Mr. Petrie, who had done a great deal in connection with the report. Professor Stoney had been so long connected with the turbine industry that whatever he did in connection with the experiments would be certain to have a utilitarian side to it. The turbine builders were paying a comparatively large sum of money year after year for this research which they would not do unless they felt they were getting a useful return. The committee, had enough work ahead of them to keep Professor Stoney and Mr. Petrie busy for some time to come, but he was going to suggest that at some future time experiments be made with nozzles of different absolute dimensions, variations of height, pitch, &c., to see how these variations affected efficiency. Professor Mellanby had referred to the simple nozzle. It has been decided to make experiments with the simple nozzle to ascertain whether, as suggested by Professor Mellanby, a simple nozzle could be adopted as a standard of reference. Speaking for the turbine builders he would repeat that they were well satisfied with the research, and he desired to express to Professor Stoney his appreciation of the admirable work which he had done.

Mr. F. B. Herbert said that a former president of the American Society of Mechanical Engineers, when retiring, said that he looked upon the future of manufacturing as being largely dependent upon engineering and upon the engineers in charge of its management and control; that only those with an engineering mind had the ability to grasp problems of production and management and also of controlling labour. As a manufacturer of small turbines, he would be indebted for the work presented that evening. On his side, the small turbine had come extensively into use as an auxiliary. His country had adopted the turbine—and many other things—originally from Great Britain, but they had developed it in large size, and, particularly, small-size work. For all power auxiliaries, for forced draught, boiler feed, circulating condenser water, oil fuel pumps and lubricating oil pumps, the use of the turbine was insisted upon throughout, particularly in marine work. Experimental work in the States had lagged behind that of this country. His society, however, in co-operation with other engineering societies, had announced that a fund of some magnitude had already been raised, and it was expected, shortly, to investigate steam at high pressures and high temperatures. Moreover, the secretary of his society was very keen on the co-operation of the British societies. If any members of the Institution cared to take part in that new experimental work it would be a great pleasure to the American Society of Mechanical Engineers to welcome them.

Mr. Telford Petrie alluded to Mr. Martin's observations on "flapping." Little had been said in the report about this point, but Mr. Martin regarded it as important. Flapping occurred when the direction of the jet made a slight angle with some adjacent solid surface. It was found that in these conditions a partial vacuum might be produced between the two with the result that the jet might be sucked in and deflected by many degrees from its intended direction. The action was an intermittent one, and had thus been termed "flapping." It was discovered in the first tests of the Parsons blading, and was responsible for the irregular results and low efficiencies then recorded. It might be added that it was detrimental to have pockets or the like on the inlet side of the nozzles. In short, both a free inlet and free exit must be provided for the steam.

Continuing, Mr. Petrie mentioned that although no theory was contained in the report, a number of students had given very effective help, and, in the course of the two or three years that the work had been going on, those men had presented theses for the higher degrees of the Manchester University. Two of those theses were to be presented to the Institution as written communications, because it was a difficult subject to talk about. One of them—from Mr. J. E. Shakeshaft—would give the discharge coefficient worked out for the tests in the report, which might prove useful to those interested in the theoretical side. Another thesis—by Mr. L. J. Cheshire—would show that probably there was a *vena contracta* effect taking place inside the nozzle; this was a difficult thing to establish actually, but arguments would be put forward to show that a *vena contracta* effect did occur, and that a full bore flow was not attained even at high speeds.

Professor G. G. Stoney then reviewed the discussion. He pointed out that in drawing up the

report care had been taken to avoid theory; only facts were recorded, and it was left to members to explain the results by discussion. The great object through all the work had been to obtain results useful to turbine designers. He might mention that he himself had been for twenty-four years associated with turbine design. During that time he witnessed the growth of the turbine from 50 h.p., or 32 kw., to 25,000 kw., and all along he had felt the great need of tests such as were now being carried out by the Nozzles Committee. As soon as he was in a position to do so, he had urged that such tests should be made, not with ideal nozzles, straight or single nozzles, but groups of nozzles, similar to those actually used in steam turbines. He felt that the results attained would be of real value to turbine designers, and that amply rewarded him for his trouble. With regard to Mr. Martin's explanation of the rise of efficiency at low velocities, he would say that the point at which the maximum occurred would depend on the dimensions of the nozzle. He had made a preliminary test on a $\frac{3}{8}$-in. Parsons nozzle instead of the 1-in. nozzle. As a result the diagram showed at low speeds the fall of the velocity coefficient predicted by Mr. Martin. He had had some difficulty in reconciling the results with the known efficiencies of moderate-sized blades in Parsons nozzles. But he believed Mr. Martin's theory to be the true one; namely, that in an actual turbine, turbulence probably arose at a very much lower velocities than in the case of the nozzle experiments. The entrance to the single set of nozzles or blades was a smooth one, but in the actual turbine, the steam entering one row of blades from the last one was in a highly turbulent state. In a recent number of the Proceedings, there appeared a paper by Mr. Dempster Smith and Mr. W. J. Walker, on "The Flow of Water through Nozzles." Plotting the velocity coefficient there given for a sharp-edged orifice, a curve was obtained which was exactly similar to Mr. Martin's curve. Further, by plotting the results obtained in a well-shaped stream-line orifice, results similar to those shown in curve 4 of the report were obtained. Professor Stoney would ask that those curves should be represented in the further discussion of the report.

Captain H. Riall Sankey (past-president) desired to confirm Professor Stoney's remarks on the absence of reasons in the report for certain happenings; it would have been unwise to have given such. The first report merely described the apparatus; the second report gave the dry bones of the facts. Work had been proceeding, and the committee hoped that the third report would be available at the end of the present year. Even then it might be unwise to give reasons for the results. He regarded Mr. Robinson's remarks as of practical value, coming, as they did, from a representative of the users, and he felt that thanks were due to the "Beama," and Mr. Robinson in particular, for the trouble they had taken and the monetary help given.

The President brought the proceedings to a close by an expression of thanks to Dr. Davis and Mr. Herbert for the kindly message from the American Society of Mechanical Engineers, and he hoped that they would return to America with every assurance of the desire of the Institution to co-operate with the American society in the research work they had in view.

ATOMIC PROJECTILES AND THEIR PROPERTIES.

ON Saturday last, at the Royal Institution, Sir Ernest Rutherford, F.R.S., delivered the penultimate lecture of his course on the above subject.

He recalled that on the last occasion he had shown some beautiful photographs by Mr. Blackett illustrating the impacts of α particles on nuclei of helium atoms, and had stated that measurements of these photographs had shown that in such collisions the ordinary laws of mechanics held. Both momentum and energy were conserved. This result was independent of any assumptions as to the law of force between the colliding systems. If, however, we wished to calculate the frequency with which such collisions occurred, we had to know the law of force applicable in such collisions.

Collisions with a nucleus were relatively rare, and many hundred photographs might be examined before seeing one. As the speed of the α particle fell the probability of such a collision increased, being proportional to the inverse fourth power of the velocity. Hence towards the end of its career the chance of an α particle colliding with a nucleus rose to something of the order of 1 per cent. In his last lecture he had also discussed the large angle scattering of α rays and shown that this must be ascribed to single impacts in which the "projectile" entered the intense field of force of the nucleus with which it collided. From a measurement of the relative number scattered through different angles it was possible to deduce directly the charge on the nucleus. Moseley had concluded that this charge was represented by the atomic number of an element. He had found that the frequency ν of the K radiation from different atoms followed the law

$$\nu = (N - A)^2$$

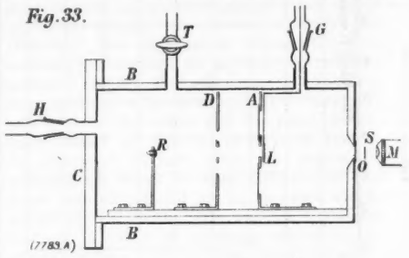
where N represented the atomic number and A a constant which was 1 for the K radiation, and 7·4 for the L radiation. He had also shown that N varied by one unit in passing from one element to the next, and it was thus natural to conclude that N represented the nuclear charge. The constant A he attributed to the disturbance of the field by the electrons surrounding the nucleus. It was important to confirm this conclusion by direct experiment, and this had been successfully accomplished by Mr. Chadwick by determining what fraction of the total α radiation impinging on a screen was scattered through different large angles. The apparatus is represented in Fig. 33. A little RaC was placed at R, and at D were interposed certain stops to define the rays. The α rays fell then on a sheet of scattering material at A, and such as were deflected through a large angle passed through a mica window at 0, and thence on a zinc sulphide screen at S. where the scintillations were counted with the aid of the microscope M. To determine from such observations the nuclear charge it was necessary also to find the total radiation emitted. To this end an opening in the centre of the screen which during the observations on scattering was covered by the shutter L, was uncovered, thus allowing the full radiation to fall on S. A difficulty that then arose was, that whilst in the scattering experiments the scintillations were of the order of 50 per minute, with the full radiation there would be about 50,000 a minute. Hence a slotted disc was interposed between the window and the screen S. This disc was kept in steady rotation, and the α particles could only pass to the screen when the slot gave them way. This slot was $\frac{1}{1,000}$ of the total circumference of the disc, and in this way the scintillations were reduced to a countable number. In this way Mr. Chadwick had obtained the following results:—

Material.	Nuclear Charge as Found by Experiment.	Atomic Number.
Copper	29·3	29
Silver	46·3	47
Platinum	77·4	78

Considering the difficulty of the experiment he thought that these observations gave a very direct proof that the nuclear charge really was equal to the atomic number, and that this assumption, which was the basis of all modern physics, was a safe one.

Mr. Chadwick's apparatus was based on the assumption that the law of the inverse square held for the collisions with which he was concerned. According to this theory the scattering should vary as the inverse fourth power of the velocity, and no other law was consistent with his results. Making correction for the effect of the K electrons it appeared that this law of force held for a region surrounding the nucleus, of which the outer radius was of the order of 10^{-10} cm. and the inner radius 5×10^{-12} cm. The question, however, arose as to whether it held right up to the very surface of the nucleus, assuming the latter to have a definite shape. An answer to this question must be found by studying the in. impact of α particles with the lighter atoms, since the case of the heavy atoms the positive charge on the nucleus was so great that the colliding particle was turned back before it reached nearer than 5×10^{-12} cm. from the centre of the atom. With light atoms a closer approach was possible, particularly with helium and hydrogen. With the former a difficulty arose from the fact that the two having the same mass it was not possible after a collision to distinguish between the projectile and the target, but observation had shown that in such impacts the normal range of the α particle was never exceeded. Hydrogen having a mass of 1 as against 4 for the α particle, we could calculate from the ordinary laws of mechanics that the maximum velocity of the hydrogen nucleus after a collision would be 1·6 times that of the α particles. Moreover, as the hydrogen nucleus carried only one charge in place of two it would experience smaller forces as it plunged through other atoms, and would travel four times further through the gas than the original

Fig. 33.



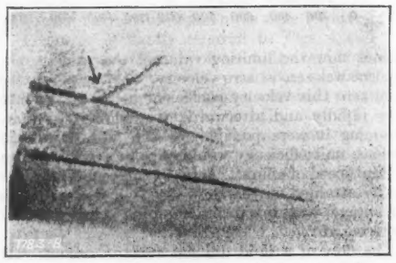
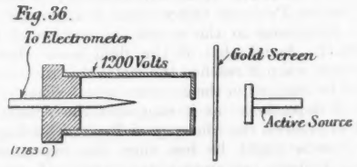


FIG. 34.

FIG. 35.

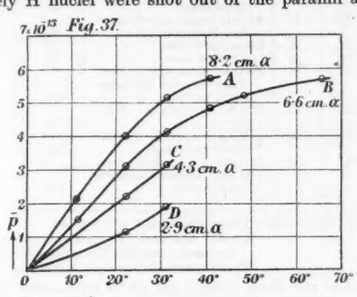
Fig. 36.

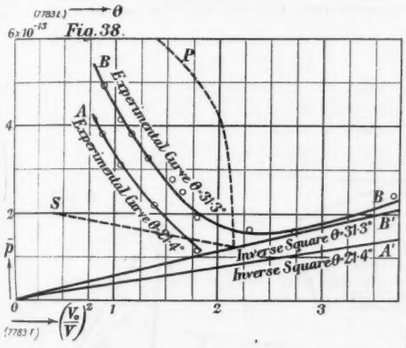


α particle. Like the latter it had a definite maximum range, and its behaviour was altogether analogous. The chance of a hit between an α particle and a hydrogen nucleus was, however, extraordinarily remote. The maximum deflection from its course of an α particle after collision with a hydrogen nucleus could not, from the ordinary laws of mechanics, be more than 14 deg. The hydrogen nuclei thus projected forward by a direct hit with an α particle were also able to produce scintillations on a zinc sulphide screen. These were not quite so bright but could nevertheless be counted.

Fig. 34 represented the first recorded collision between an α particle and a hydrogen nucleus. Over 1000 photographs were taken and examined

before this was found on one corner of a plate. Since then Mr. Blackett had obtained photographs of such collisions in a Wilson expansion chamber, the photographs being similar to Fig. 31 on page 339 *ante*. By measuring the angles between the traces left after the collision it was possible to calculate the mass of the target collided with. Mr. Blackett had thus obtained 1·024 as the mass of the hydrogen atom as against the recognised value of 1·008. It was Mr. Chadwick who had first obtained tracks of swift H particles in a Wilson expansion chamber. He fired α particles into a block of paraffin and very rarely H nuclei were shot out of the paraffin and





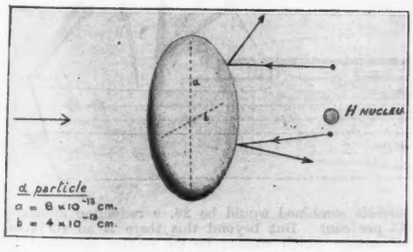


FIG. 39.

into the chamber, where they ionised the air just like an α particle. The tracks, however, were longer, measuring from 10 cm. to 15 cm., and the ionisation per centimetre of track was less intense. For the same speed it would be only one-quarter as much as that produced by the α particle, and the speed of the hydrogen nucleus was higher. Fig. 35 was interesting, for in this the hydrogen nucleus having been shot forward out of the paraffin as described, was now doing the same trick on its own account and colliding with the nucleus of a nitrogen atom. The nitrogen atom being so much heavier than the hydrogen nucleus, its recoil was represented by merely a spur on one side of the track.

The production of swift hydrogen nuclei could also be demonstrated electrically, using a Geiger counter, the arrangement being as indicated in Fig. 36. This detector consisted of a needle point at the centre of a brass tube, from which it was insulated, and connected up to a string electrometer. A little window to the right of the tube allowed charged particles to be shot into the interior. There was a potential difference of 1,200 volts between tube and needle, and the entrance of one of these particles led to so much ionisation that the electrometer was deflected, and these deflections could be automatically recorded. The lecturer demonstrated this by using a source of α rays emitting some 30,000,000 per second. The whole of these were excluded by a gold screen. By placing a little paraffin over the gold, occasional hydrogen particles were shot out of this by the impact of α rays, and having a higher penetrative power than the latter, got through the screen and operated the detector.

It was now, Sir Ernest proceeded, some five years since he had shown that by the impact of an α particle a hydrogen nucleus might be shot out with a speed 1·6 times that of the α particle. At the same time, he had made measurements of the number of such swift particles produced. This depended on the law of force, and assuming the interacting nuclei to be point charges repelling each other according to the law of inverse square, we could calculate the number of α particles sent off at different angles.

Observation showed, however, that the actual number was very much greater than such a calculation would indicate, in some cases 20 or 30 times as great. In some recent experiments Mr. Chadwick and Mr. Beiler had been able to determine with accuracy the number of hydrogen nuclei deflected through different angles by the impact of α particles. According to past experience with heavy atoms, this number should increase as the speed of the α particles fell, the frequency of an ineffective collision varying as the inverse fourth power of the speed. What they actually found is represented in Fig. 37, where on the contrary the number of collisions made diminished with the range and consequent speed of the α particles. In fact, in some cases the number of effective collisions was 100 times as great as if the nuclei had been point charges, and the simple laws characteristic of collisions with heavy atoms thus broke down completely when hydrogen was the element bombarded. This was due in the first place to the projectile being able to get much nearer to the hydrogen nucleus than it could to the nucleus of an atom of gold.

In trying to find out the law of force applicable to these collisions with hydrogen, it was convenient to assume that all the complexity belonged to the more complex α particle and that the hydrogen nucleus could be represented by a point charge. One assumption made had been that the α particle could be represented by a flat, perfectly elastic disc, the path laying along the axis of this disc. On this assumption, Mr. Darwin had calculated the amount of scattering produced, and had also made a corresponding calculation in which the α particle was represented by a perfectly elastic sphere. The conceptions were, of course, highly artificial ones, but they led to the result that in accord with observation the number scattered through definite angles fell off as the speed diminished. In Fig. 38, Mr. Darwin's calculation for the plate and sphere are represented by the dotted lines marked P and S, respectively, and the experimental curves of Chadwick and Beiler are also shown, as well as straight lines representing the results if the law of the inverse square held. It would be seen that the results were intermediate between the calculations for the sphere and the plate, and are well represented by assuming the α particle to be an oblate spheroid having the dimensions indicated in Fig. 39.

It was assumed that the collisions between this spheroid and the hydrogen nucleus were perfectly elastic. Outside this spheroid the law of the inverse square held. This representation was, of course, highly artificial, since we knew that the α particle was not an elastic plate or spheroid. In actuality the surface of the spheroid was not a mere elastic reflector, but the repulsive force increased with very great rapidity when a hydrogen nucleus penetrated this surface. The forces involved were enormous and far beyond any conception we could form as to those acting in mechanical collisions. In these close approaches a whole multitude of things might happen. The whole structure of the α particle might be, and probably was, distorted, but in general the speaker had been led to the conclusion that we got in these cases to a new law of force varying perhaps as the inverse cube or the inverse fourth power of the distance between the centres. There might be magnetic forces developed in the nucleus due to a rotation of its parts. We had, in fact, to introduce other conceptions than the Newtonian law of force, and got thus to a kind of micro-astronomy which he himself found more interesting than the ordinary type.

A PROPOSED AIRCRAFT CARRYING MAIL STEAMER.*

By SIR EUSTACE D'EYNCOURT, K.C.B., D.Sc., F.R.S., Vice-President, and Mr. JOHN H. NARBETH, C.B., C.B.E., M.V.O., R.C.N.C., Member.

IN describing "Naval Construction during the War," before this Institution in 1919, some reference was made to the production of aircraft carriers for naval purposes; and it was stated, "There is no question that aircraft carrying will gradually become more important for the fleet." The few years which have since elapsed have fully confirmed that opinion, and the value of the aircraft carrier for naval purposes is indicated by the large sum of money voted in the current Navy Estimates for that class of work.

The experience gained in the naval aircraft carriers indicates that flying on to, and off from, ships at sea is rapidly becoming thoroughly practicable. Some six hundred successful flights on to H.M. ships Argus and Eagle have already been made, under varying conditions of weather, at sea. It may well be that we are now advancing to a position in which the aircraft carrier will become relatively quite as important a ship for the mercantile marine.

At the Air Conference held at the Guildhall in the autumn of 1920 a suggestion was made by one of the principal speakers to consider the practicability of carrying aircraft on mail steamers. At that time some experience had been gained in fitting up mail steamers, *e.g.*, the Australian Government steamer Nairana had been fitted out as a seaplane carrier. Stowage was provided for seven seaplanes, and derricks were provided for hoisting them in and out. This, however, was a very cumbersome method and totally different in conception from the aircraft carrier as specially developed for naval purposes. The carrying of aircraft in mail steamers had also been approached at that time from quite a different point of view, viz., as a supplementary naval service, and the Director of Naval Construction was able to state that an outline design had been prepared for an aircraft carrying mail steamer, which could accommodate about 20 aeroplanes of moderate size, in peace-time, and a larger number if required in case of war.

The question has now been further investigated, and drawings are attached to this paper showing what is hoped may be the basis for a practical discussion on the possibility of an aircraft carrier regarded, not as a supplement to naval services, but as a special development of the mercantile marine; and, by the methods described later, it will be seen that, in the proposed vessel, which is of quite moderate dimensions as compared with the leading Atlantic liners, besides providing all the facilities required to complete the vessel as a commercial, mobile aerodrome, there will remain ample deck spaces for accommodation of all kinds and particularly an enormous open upper deck available for recreation, besides large protected areas on the next deck beneath it. The cabin accommodation provided is about 80 per cent. of that of Mauretania for first and second-class passengers, and 40 per cent. for third-class passengers, although the vessel is much smaller, and large spaces are set apart for aircraft.

AERONAUTICS AND NAVAL ARCHITECTURE. SISTER SCIENCES.

The science of aeronautics and that of naval architecture are inter-related at many points. The mathematical treatment of many problems common to the two sciences is identical, and in the practical development of aircraft construction a knowledge of the practical side of naval architecture, *i.e.*, shipbuilding, has proved a very great advantage.

As regard airships, the problems of flotation, propulsion, resistance, stability and manœuvring have their counterparts in those of the submerged submarine. The problem of flotation led to many devices and developments in submarines in order to secure the greatest operating and offensive power on the displacement accepted, and many of the inventions and researches therein have been of great value as pointing to correct paths of development in the design of details and in the use of materials for the structural portions of the great rigid airships. Similarly, many years' actual experience respecting the positions, relative sizes, and forms of rudders for manœuvring submarines in the horizontal, and in the vertical plane, proved of the utmost value in the early stages of airship design, pending the development of airship practice and experience.

Then again, heavier-than-air machines have certain problems in common with sailing vessels, and motor boats, and surface vessels generally. Questions of steering, of the magnitude and distribution of pressure on rudders, led to investigation, both mathematical and experimental, relating to the flow of water past inclined surfaces such as immersed planes of various shapes, which have been the foundation from which the investigation of wind pressure, on the various portions of the aeroplane have been developed. The practical and scientific questions relating to the form, pressure of wind, and resultant effect of sails in ships and boats were all of the greatest value to early builders of aeroplanes.

This subject has been very clearly developed by Constructor-Commander Jerome C. Hunsaker, U.S.N., whose work has contributed very much to the development of the designs of United States Naval Aircraft. In the Wilbur Wright Memorial Lecture, which he delivered before the Royal Aeronautical Society on June 22, at the Central Hall, Westminster, he developed this thesis in a most convincing manner. A full account

* Paper (slightly abridged) read at the Spring Meetings of the Institution of Naval Architects, March 21, 1923.

of the lecture may be found in the journal of the Royal Aeronautical Society, and in ENGINEERING of June 25, 1920.

Aeronautics and naval architecture are in fact sister sciences, which render to each other assistance of the greatest value subject as they are to the influence of common laws, and the aircraft designer who is first a competent naval architect starts with a great deal in his favour. This was fully realised both by the Admiralty and the Air Ministry, and acted upon very definitely by drawing upon the Royal Corps of Naval Constructors to carry on the work of lighter-than-air craft design and construction in this country. It is also recognised in the United States, where the naval constructors form the backbone of the design and construction departments of the Naval Air Service, and to this is due to no small extent the very great success which the United States Naval Air Service has achieved in the development of flying boats of great capacity, speed, and durability as shown by the extensive manœuvres which their flying boat squadrons have carried out without aid from any other service.

AIR TRANSPORT AND MERCHANT MARINE. SISTER SERVICES.

Similarly, the successful employment of aircraft and of shipping are subject to corresponding economic laws of the simplest character. Air transport and the merchant marine do in fact constitute sister services. On the water there are the slow cargo carriers, the fast steamers for mail and passenger services, and the faster motor-boats for pleasure or business. So in the air services will be found the comparatively slow weight-carrying aeroplanes, the faster aircraft for regular mail and passenger services, and the still faster sporting machines which may also be utilised for business.

Much discussion has taken place as to the vital connection between the fighting navy and the fighting air services in all countries, and the time has now arrived when national consideration is demanded, respecting the relations between the mercantile marine and the mercantile air services. Both are controlled by the same laws of supply and demand, and of volume and distribution of business, resulting in profit or loss according to the means and methods of handling the business.

World-wide air services mean world-wide traffic which will be of sufficient volume, and must be sufficiently remunerative to pay all the expenses incidental to running the aircraft; maintaining them in efficient condition; providing adequate bases at a sufficiently large number of points to collect the traffic, in order to give all facilities necessary to rest the pilots and to refit the machines; and finally, to pay interest on the capital invested.

If such traffic be run in competition with steamship services, it will always be liable to disorganisation by concerted action of the groups of steamship companies whose trade would be affected, but so far as can be seen at present there is but little hope of the necessary capital for any very extended heavier-than-air service becoming available without State aid, nor are there any prospects of very large opportunities of transport across new routes which cannot be in some way served by steamship and rail services.

PRESENT POSITION OF BRITISH AIR SERVICES.

The United Kingdom is not a promising field for extensive air services. The centres of population and industry are separated by no very large distances, and they are connected by very efficient and rapid railway services which deliver passengers and goods alike into the heart of the most crowded cities. Gain of time in travelling by air is very largely set off by the necessity of landing in a safe place remote from the centres of population, so that the terminal losses of time are of relatively great importance and form a more or less effective handicap to British air service developments within the limits of these Islands. To proceed from the United Kingdom to any of the other important portions of the Empire, on the other hand, involves traversing such immense distances as to be almost impracticable for heavier-than-air craft, not to speak of the necessary rights of way over foreign countries.

AIR CONFERENCE, 1923.

Visitors to the National Aerodrome at Croydon on February 5, this year must have been struck by the great advances in general design and in the clean and finished appearance of the machines then shown, as well as in the increased flexibility and reliability of the engines, and the ease and comfort of manœuvring of the several machines by their pilots. The improvement in landing was particularly noticeable. The most striking feature was, however, the great durability shown by the machines, such as an Instone liner—or D.H.4 machine—with 370-h.p. Rolls-Royce engines, which had been in continuous service for over three years, and had several hundreds of return trips to France to its credit; and a D.H.4 All Red machine, with 450-h.p. Napier Lion engine, which had covered over 110,000 miles in the previous ten months and was still apparently in the best condition. The new fighting machine (Avro Bomber), with its engine of 1,000 h.p. (Napier Cub) fitted with a gas starter, was also a sign of the great general advance now in progress.

These things are mentioned, as they indicate the promise of such further developments as may be necessary to produce efficient and durable machines specially suited for the purposes indicated in the present paper, which would, however, probably be of one of the amphibian varieties, which have been very much before the public in recent years, although not in evidence at Croydon on that occasion.

OVERSEAS AIR SERVICES.

Countries which have important centres of population at considerable distances apart, such as France, Germany, and more particularly the United States of America, have found that aerial communication can be made to pay on long overland routes, particularly where the railway communication is not very direct.

The question therefore arises, "Can any practical proposals be made which will place British commercial air services on a more satisfactory basis?" It is suggested that this can perhaps be done by making use of the great commercial interests and the routes of commerce now held by British steamship companies, and by regarding the air service as the handmaid of the steamer service.

On land ordinary goods trains run from one goods yard to another, and the goods are distributed from these strategic points to the customers by motor lorries. Passengers are conveyed in the same way from one centre of population to another by express trains, the distribution from the strategic centre of population taking place by motor cabs or other conveyances, and it appears that this is precisely the kind of service that the motor aeroplane, recently called the taxi-plane, can render to the steamship or the motor-ship. If the combination can be arranged, the aircraft would assist the steamship services to fulfil their functions as ocean carriers of passengers, mails, and merchandise, and this would offer a much more attractive prospect than that of entering into an undesirable competition with the steamship services.

The essential consideration in merchant ship transport and in air transport is that the business must pay. Long experience has shown that the tramp steamer is about the cheapest means of transport which provides its own means of locomotion, and that the costs gradually increase as more refined methods are called into use.

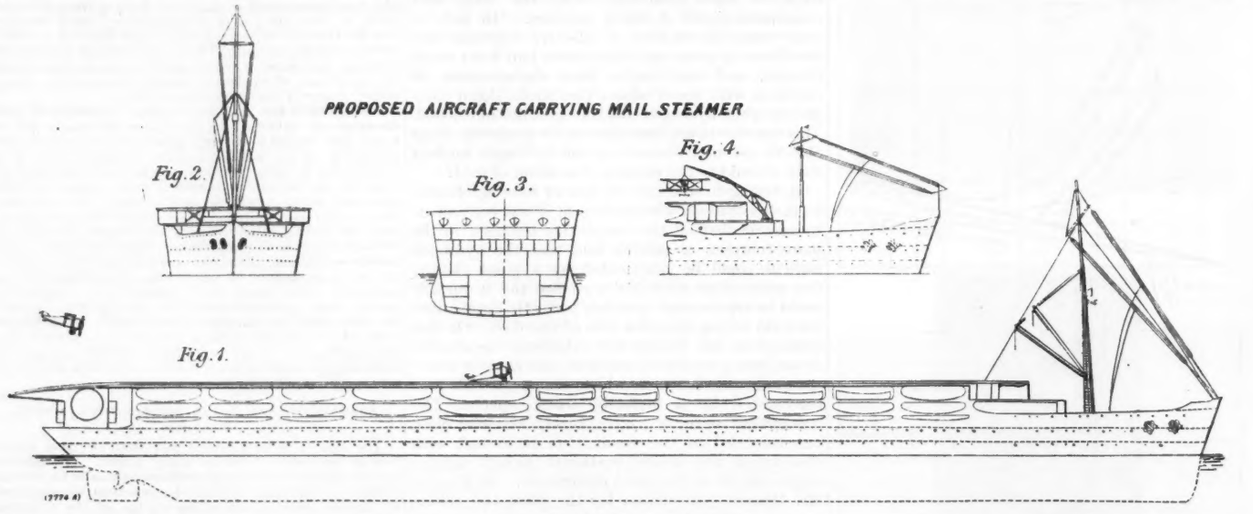
A most informing table of the relative costs, per mile-ton, for various methods of transport, was published in *The Engineer* of November 17, 1922. Fifty cases were cited, and the basis for the estimate of cost, or reference thereto, was furnished. Some figures are quoted in the table in the next column.

The economical gain by the proposed method of combined transport, as compared with an all air service, can be inferred from the figures given. For instance, if five-sixths of a journey can be done by steamer (No. 26) and one-sixth by aeroplane (No. 41), and the cost of the whole journey per air be represented by the figure of 100; then the figure for cost by steamer and aircraft combined would be 26, a reduction of nearly 75 per cent. But beyond this there is an enormous advantage which cannot be so readily estimated by supplying quick communication to places not now regularly served, and by coupling up outlying part of the Empire, with the ordinary means and routes of commerce.

TABLE I.

No. in Table.	Reference.	Method of Transport.	Speed, M.P.H.	Cost per mile-ton, pence.
2	A	Tramp steamer	7½	½
4	A	Steam goods train	15	1
7	C	Leyland 3-ton lorry ..	8	4
9	C	Airship (rigid), Commander Burney (1922)	80	4
11	A	Steam passenger train (third class)	40	6
19	C	Airship (rigid), Air-Commodore Maitland, 1919 ..	60	21
21	A	Liner (third class)	12	24
26	A	Liner (first class)	12	53
31	B	Private Company's Aeroplane Service (London-Paris, parcels)	100	144
35	B	U.S.A. Aeroplane Postal Service	90	240
40	B	G.P.O. Aeroplane Service (Cairo-Baghdad)	100	480
41	B	Private Company's Aeroplane Service (London-Paris), letter	100	492

Reference.—Those marked A are proved.
Those marked B are according to present charges (November 17, 1922.)
Those marked C are estimated.



LESSONS FROM NAVAL AVIATION.

Before entering on a definite proposal, it may be as well for a few moments to refer briefly to the progress of naval aviation. Prior to the war an 11-knot merchant ship, the Ark Royal, was taken up, redesigned and fitted out as a seaplane carrier. She was provided with a hangar, workshops, means of hoisting the seaplanes in and out, and handling them generally, and she was provided with a flush, horizontal forecastle deck about 180 ft. long from which a seaplane could fly off by the aid of wheels which were dropped into the sea when the seaplane cleared the ship. That vessel was quickly completed after the war began, and hurried to the Mediterranean, where she remained and rendered excellent service. The combination of steamship and aircraft proved a complete success in that case.

At a later date the old Atlantic liner, Campania, was also taken up and fitted as an aircraft depot, and aeroplanes and seaplanes were flown off from an elevated platform built on the forward part of that ship, and this combination was also very successful.

The idea of returning directly to the ship instead of landing on the water and being picked up by a derrick or crane immediately arose in both ships. It was a very attractive one, and a scheme was drawn up in the Constructive Department of the Admiralty, by which it was proposed that the Campania should be provided with a system of wires stretched from a transverse boom fixed near the stern of the ship, to another strong beam fitted near the after funnel. The aircraft were to fly on to this system of parallel wires which sloped upwards and forward, from the boom to the beam. This was not, however, developed to a working arrangement, but the pursuit of the idea was carried out by the Naval Air Service and the Constructive department jointly with

PROPOSED AIRCRAFT-CARRYING MAIL STEAMER.

Fig. 5.

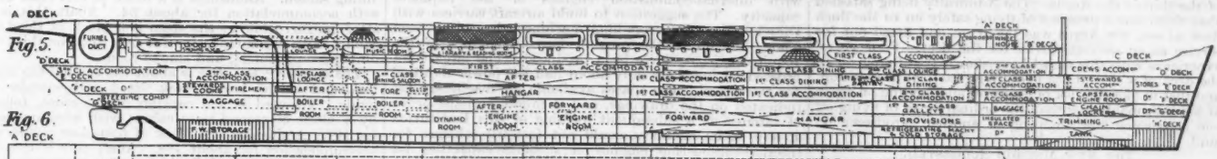


Fig. 6.

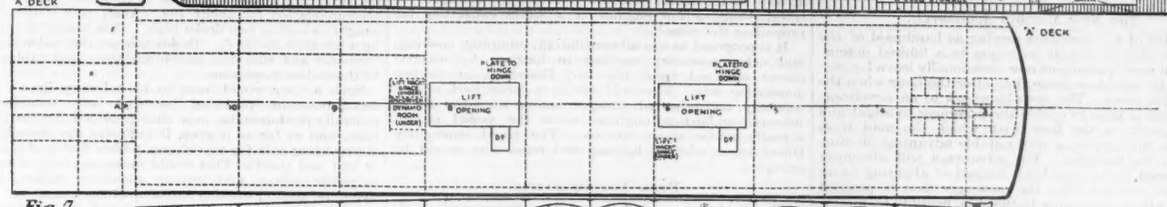


Fig. 7.

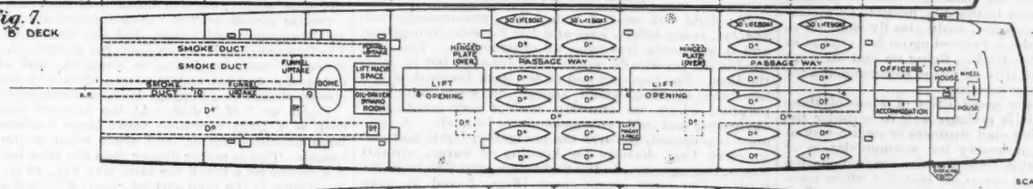


Fig. 8.

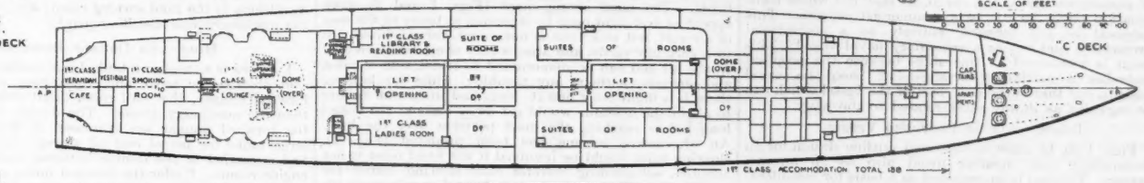


Fig. 9.

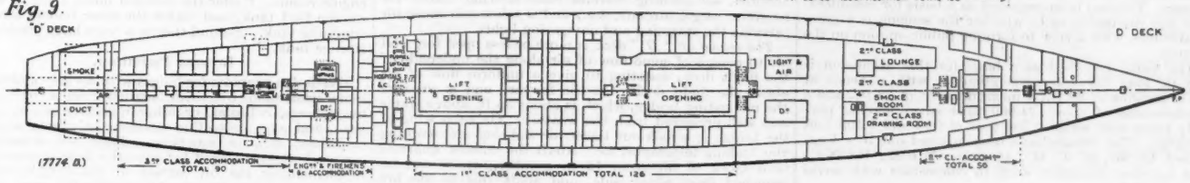


Fig. 10.

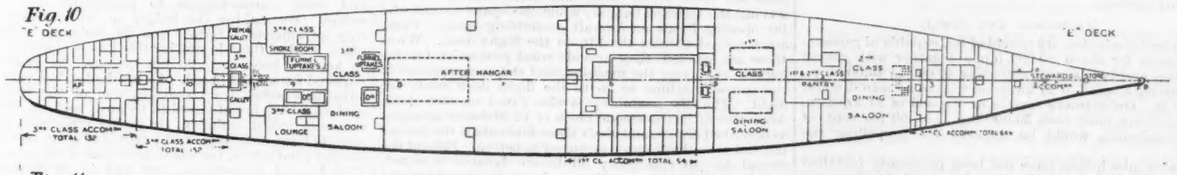


Fig. 11.

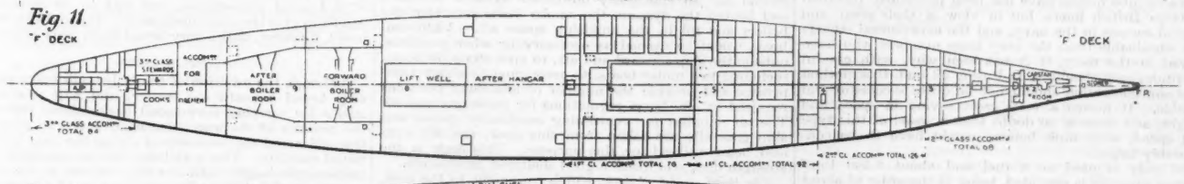


Fig. 12.

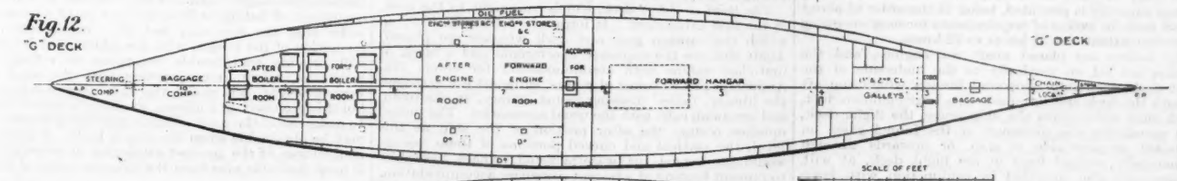


Fig. 13.

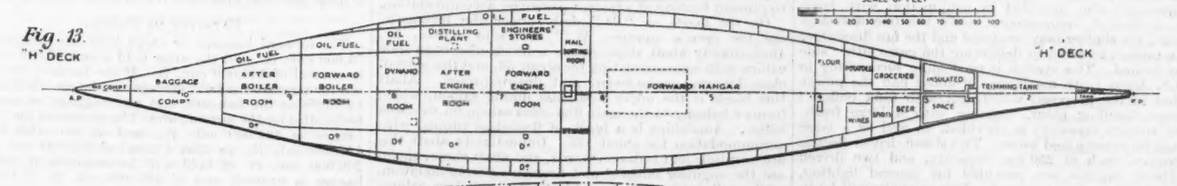
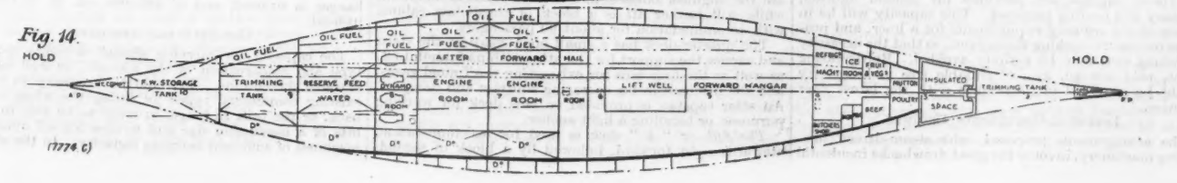


Fig. 14.



Messrs. Beardmore, who made the somewhat startling proposal to carry the funnels horizontally to the stern of the ship in the Argus. The Admiralty being satisfied that there was a prospect of flying safely on to the flush deck at sea, the Argus was taken up and fitted out for service as an aircraft carrier for the fleet. Four years' experience with this vessel have shown that flying on to the deck of a ship at sea is quite a practical proposition, and that in fact the risk of flying off and landing on again at sea is probably less than the ordinary risk of flying off one aerodrome and alighting at another aerodrome on land.

The New Method Suggested.

The idea of the aeroplane serving as handmaid of the merchant ship is already in vogue to a limited extent. In case of need, passengers now occasionally leave London or Paris by aeroplane some time after the hour when the mail trains leave. The aeroplanes get to an aerodrome at the port in time to enable the passenger to alight and then embark on the liner with which the mail train connects, thus giving a very notable advantage in time saved to the traveller. The advantage will obviously be increased if the aeroplane, instead of alighting at an aerodrome and requiring the passenger then to proceed by some other conveyance to the ship, possibly by motor-car and also by ferry steamer, could also fly right on to the ship herself while she is proceeding on her voyage at sea. Should this be practicable, flying on and off ships at sea opens up a great vista of future developments for combined air and steamer services.

Before mentioning the possibilities of some of these future developments, it is perhaps well to consider the practicability of building mail steamers in such a way as to offer the facilities necessary for accommodation of aircraft and at the same time for the accommodation of passengers, mails, and cargo, so that the whole combination might be run as a commercial concern. This proposal is put forward entirely as a commercial proposition and not as a subsidiary naval vessel. This point is mentioned at this stage because the proposal embodies a machinery arrangement based on naval designs, but that is the only part of the vessel which can be regarded as in any sense related to the navy.

Description of Proposed Vessel.

Figs. 1 to 14 show a suggested outline design for an ocean-going mail steamer fitted also as an aircraft carrier. This has been prepared as a basis for consideration and discussion as to whether the scheme is a practicable one, with a view to forming public opinion on the matter.

The vessel proposed as a basis for this discussion is 600 ft. long between perpendiculars with a beam at the water-line of 80 ft., a mean draught of 28 ft., and a displacement of about 24,000 tons when leaving port fully laden with about 2,500 tons of fuel and 1,500 tons of cargo. The details have been worked out to a large extent by Mr. C. J. W. Hopkins, M.B.E., R.C.N.C., who has done excellent work in connection with naval aircraft carriers.

Machinery and Speed.

Water-tube boilers are provided for, capable of generating steam for about 50,000 h.p.; together with geared turbines and twin screws absorbing 40,000 to 45,000 h.p., and giving a speed of 24 knots on trial at a mean draught of 26 ft. On ordinary service at a speed of 21 knots to 22 knots not more than 30,000 h.p., i.e., 60 per cent. of the maximum, would be required for propelling the ship.

Water-tube boilers have not been previously installed in large British liners, but in view of their great and general success in the navy, and the experienced stokers now obtainable from the very large numbers who have served in the navy, it is not seen why, with careful attention, easy steaming, and using oil fuel, this method of steam generation should not be quite successful and reliable. It means a very great saving in space and weight, and there is no doubt that a vessel of this type and speed, with tank boilers, would have to be considerably larger.

Oil only is used as a fuel and about 2,500 tons' storage capacity is provided, being of the order of about 50 per cent. in excess of requirements for easy steaming across the Atlantic at 21 knots to 22 knots.

The boilers are placed abaft the engines, and the uptakes are led up vertically to the underside of the flight deck, then into horizontal funnels which run aft beneath the deck and terminate in a large common duct, which runs right across the ship under the flight deck, thus permitting the discharge of the funnel gases on starboard or port side of ship, or upwards through mechanically worked flaps in the flight deck, at will. Shutters are also provided in conjunction with large fans, so that if circumstances make the free discharge difficult, the shutter may be closed and the fan discharges set in motion to assist in delivering the gases either side when desired. This system is used quite successfully in H.M.S. Argus (with machinery of about half the power of that in the proposed vessel, but with tank boilers.) A large distilling plant, together with a large fresh-water storage capacity, is provided, as well as a large storage for reserve feed water. Two steam-driven electric generators, each of 250-kw. capacity, and two driven by Diesel engines, are provided for general lighting, culinary and heating purposes. This capacity will be in excess of the ordinary requirements for a liner, and provides for electric cooking throughout, so that the necessity of taking coal may be entirely avoided. Refrigerating plant, cold storage, &c., of suitable size and capacity would be provided in accordance with the latest liner practice.

Internal-Combustion Engines.

The arrangements proposed, with steam-driven propelling machinery, involve the great drawbacks incidental to large funnels and uptakes, but the general design of the vessel would remain if it were possible to fit her with internal-combustion engines of the requisite capacity. The suggestion to build aircraft carriers with Diesel engines for propelling machinery has often been made, but up to the present date no engines of the required capacity have been produced. The largest yet ordered for liners are only about half the power required for this vessel. The spaces available for machinery are indicated on the drawings, and it might perhaps prove of interest at a subsequent meeting of this Institution if any of its members could put forward schemes for internal-combustion engines of suitable capacities for propelling the vessel.

It is proposed to run all ventilating, pumping, cooking, and other necessary services in harbour by electric power obtained from the two Diesel-driven electric generating sets. This will secure a large part of the economy, and other advantages, arising from the use of internal-combustion engines, while the vessel is not actually under steam at sea. The usual emergency Diesel-driven electric lighting and radio sets would be provided.

Deck Accommodation.

The flight deck or "A" deck is approximately rectangular, being 565 ft. long and 100 ft. wide throughout, and it is entirely free from all obstructions. The deck finishes off practically square at a position 100 ft. from the bow. The tapering end of the deck forward, which has been omitted, would appear to serve but little purpose, whilst its omission enables very satisfactory navigating and cable arrangements to be made. A foremast is proposed, to carry the navigation lights and also to carry long derricks for hoisting of cargo, aircraft stores, baggage, &c., to the flight deck, and thence to the holds. The mast arrangement (Figs. 1 and 2), may appear at first sight open to objection as being in the way of aircraft, but this view is not sound, for machines rise in a very few yards, and after a very short time are well in the air and can be manœuvred to either side of mast and shrouds, without any trouble; while for landing there is a flight deck 565 ft. long, and in case of failure to alight the machine would get away clear of the vessel long before reaching the mast position over the bow. An alternative scheme has been prepared (Fig. 4), showing what would be involved if the fixed mast is not adopted, substituting therefor close stowing cranes for handling cargo, aircraft, &c., and a telescopic mast for carrying the steaming and navigating lights.

The second or "B" deck is more or less open fore and aft to permit of some flow of air along the underside of the flight deck, assisting to give a uniform flow of air above the flight deck. At the forward end is situated the navigating bridge, which is about 35 ft. above water and well protected from the weather. On each wing of the bridge is a look-out tower for sighting aft, working the docking telegraphs, &c. Abaft the officers' quarters is a block of lifeboats, 12 in number, which can be launched from either side, and abaft this is the lift serving the forward hangar, while the space around the lift opening forms an aircraft assembling space. Flaps are arranged abreast the lift, in the flight deck. When these are lowered, they provide wind protection for the purpose of rigging the machine, and the openings enable the spread machine to go to the flight deck ready for flight. The lift machinery is also fitted on this deck. Abaft this lift is the second block of 12 lifeboats arranged as described above, and abaft these lifeboats is the second lift and assembling space arranged as before. Behind the second lift an emergency oil-driven dynamo is fitted, and behind the dynamo the smoke ducts rise from the boilers and fill in the amidship space aft. Additional boats would be carried as necessary in other positions, outside the ship forward and aft, to give about 30 boats, including two motor-boats, to accommodate about 1,800 persons and provide the number of launching positions required by the latest regulations for passenger vessels. The air supplies for ventilating machinery spaces and ship generally are taken from this deck, the lift wells also being utilised for this purpose. This deck is the strength deck and forms a good sheltered promenade.

The third or "C" deck, which runs right to the bow, is the first cabin deck. It forms the forecastle deck, on which the capstan gear and deck winches are placed. Abaft this are the captain's apartments and a block of first-class cabins with accommodation for about 138. Amidships are 10 suites of rooms, while aft are arranged the library, ladies' drawing-rooms, lounge, smoke-room, and verandah café, with the usual accessories. The funnel uptakes occupy the after portion of the ship at this level, the vertical and curved portions of these casings would be lagged, or waterjacketed, where desirable, to prevent heating of adjacent passenger accommodation.

On the fourth or "D" deck, under the forecastle, are the crew's quarters, W/T or radio offices, &c. Immediately abaft these comes a block of second-class cabins with accommodation for about 56, and the second-class lounge, smoke-room, and drawing-room. Abaft this block is the upper first-class dining saloon, which forms a balcony to the main first-class saloon on the deck below. Amidships is a block of first-class cabins, with accommodation for about 126. Immediately abaft this are hospitals and isolation wards, and abaft these, again, are the engineer officers' and firemen's accommodation, while still farther aft is a block of third-class cabins, with accommodation for about 90 passengers.

The quarter-deck has a small open space at the stern and carries the support for the athwartships funnel duct, as well as the four fans for exhausting the funnel gases, and the mechanism for operating shutters and dampers. An after capstan is provided on this deck for working purposes, or handling a light anchor.

The fifth or "E" deck is used for accommodation, stewards right forward, followed by a block of second-class cabins with accommodation for 64. Abaft this is a second-class dining saloon and the main first-class dining saloon. Amidships is a block of first-class cabins with accommodation for about 54. Abaft this is the after hangar, while at the stern is a block of third-class cabins, with accommodation for 284, and the third-class dining-room, lounge, and smoke-room.

The sixth or "F" deck is about the level of the water-line, and is the lowest deck fitted with circular side lights. Forward is the capstan engine-room, followed by a block of second-class cabins with accommodation for 194. Amidships is a block of first-class cabins with accommodation for about 168. Abaft this is the after hangar, which is two decks high. This hangar is served by a lift 46 ft. by 24 ft. Beside this are the boiler-rooms, firemen's and stewards' accommodation and cabins for 84 third-class passengers.

Such a liner would have to be a luxury liner. The accommodation provided for first and second-class generally predominates over that provided for the third class, and so far as it goes, it indicates the desirability of providing only for two classes (either first and second, or first and third). This would mean economy of space in public rooms, and greater space for cabins, and, therefore, greater earning capacity of the vessel.

On the seventh or "G" deck forward are the galleys, &c., baggage hold, chain lockers, and ships' stores. The forward hangar is just abaft the galleys. Amidships, stewards' accommodation is arranged, and abaft this follow the turbine engine-rooms, dynamo-room, boiler-rooms, stores, &c., baggage hold, and steering gear.

Eighth or "H" deck.—At the forward end of this deck is a large trimming tank, large insulated stores, large provision stores, and abaft them is the forward hangar. This is rather deeper than the after hangar, and it is served by a lift of the same size, viz., 46 ft. by 24 ft. Amidships is the mail sorting room, &c., and abaft this the machinery and distilling plant.

Hold and Double Bottoms.

Forward is a trimming tank, large insulated stores and cold storage for meat and vegetables, &c., then the forward hangar, the mail room abaft this hangar, and then the machinery spaces. The double bottoms under the forward hangar are increased in depth and form large tanks for petrol and oil storage for aircraft. Oil fuel is carried in the double bottoms under the turbine engine-rooms. Under the forward boiler-room is a large reserve feed tank, and under the after boilers the large trimming tank. Behind this is a very large fresh-water storage tank.

Bulges Provided.

The design provides for bulges with a view of obtaining some protection by them against results of damage by icebergs, collision, or other misadventure in peace-time, and as a protection against the effects of mines, torpedoes, &c., in war-time. They are arranged to carry oil when required for specially long voyages, thus supplementing the oil carried in the double bottoms and wing compartments to practically any desired extent. By making the bulges an integral part of the ship an efficient "form" can be designed in the first place, so that they do not involve loss of speed, or stated in another way, they do not increase the horse-power required for a fixed speed. An incidental, but very great, advantage arises from the adoption of the bulge. It enables a very broad vessel to be built without involving excessive initial stability, or undue resistance, and so permits large deck areas to be provided at an economical cost for production, far less indeed than if the vessel were of the usual proportions, and had to be increased in length to give the same deck areas. It should be remembered, however, that a very broad flight deck is essential.

Stabilisers.

Although the addition of the bulge will make the ship very broad beneath the water, and will provide the means for carrying very broad decks above the water, the breadth at the water-line itself is not so great, and this will avoid the necessity of giving the ship too much initial stability. The initial stability as measured by the metacentric height with the ship at rest in the various conditions of lading, will be kept as small as possible in order that the ship may not be a quick roller. The formation of the bulges, with the addition of bilge keels, will provide considerable resistance to rolling. This resistance, taken in conjunction with the small metacentric height, will make the ship very steady at sea, but it is proposed, in addition, should it be found desirable to make use of the most efficient stabilizing devices which may be obtainable when the ship is built. A steady ship is of course, of the greatest attraction to passengers, and is most desirable also from the aviation point of view.

Capacity of Holds.

The forward baggage or cargo hold has a capacity of 78,000 cub. ft., and the after hold about 27,000 cub. ft., or a total of 105,000 cub. ft. If the hangars are not in use for aircraft the hold storage can be greatly increased by utilising the hangars, and any baggage or cargo can be handled by the aircraft lifts. The volume of the forward hangar is 161,000 cub. ft., and of the after hangar 117,000 cub. ft., so that a total of 222,000 cub. ft. or 266,000 cub. ft. of hold will be available if only one hangar is utilised, and of 383,000 cub. ft. if both are utilised.

Capacity for Aircraft.

The capacity for carrying aircraft depends upon the type and construction of the aircraft, as well as their extreme dimensions. It would be necessary to modify existing commercial types by fitting the wings to fold back, or the tails to hinge, in order to be able to adopt lifts of a reasonable size and to stow a good number of machines of sufficient carrying capacity. In the absence

of such types an estimate of capacity for stowing naval types of aircraft has been made with the results shown in Table II.

TABLE II.

Machine.	Forward Hangar.	After Hangar.	Total.
Torpedo carrier (Sopwith Cuckoo)	10	8	18
Parnall Panther	11	10	21
Nieuport Night Hawk	12	9	21

In making these estimates the machines are assumed to be folded, or stowed closely, but leaving the lifts empty and a clear space for one machine near each lift. The stowages are alternative, *i.e.*, in each case the hangar is completely occupied by one type of machine only, as shown in column 1. When the demand is small only one hangar need be used, giving room for 8 to 12 machines, while if both hangars are used, from 18 to 22 machines of the types named can be taken.

The outside dimensions of the machines taken compare with commercial machines as shown in Table III.

It would probably be found in the course of a short time that "joy rides" from the ship would be very profitable, and small two-seater machines could be provided for such a purpose. By this means on many routes passengers could view towns and country of great interest from the air, without going ashore, or stopping and on their route, without stopping, could serve Lisbon, Gibraltar, Algiers, Malta, and Naples. They could then run from Suez to Colombo and deal with mails for Port Sudan, Khartoum, Aden, Somaliland, and possibly Bombay, while on the run from Colombo to Sydney, various other aerial services could be maintained.

(*c*) Vessels running from Vancouver to Hong-Kong, or Australia, could in the same way deal with Pacific Islands and ports.

The Scheme Applicable to Airships.

Should any of the proposals for lighter-than-air services mature, the airships employed could work in connection with the proposed aircraft carrying steamship services, and as both of these services are developed, increasing opportunities would arise for communicating with outlying portions of the Empire by airship connections, as mooring and towing arrangements could be provided in the carrier enabling the airship to moor to the steamship, and to embark or disembark passengers, mails, and cargo for business or for pleasure, thus becoming the distributing agents for specific districts where the airships are accommodated. Tests carried out during the war show this to be quite practicable. Arrangements could also be made for this steamship to carry and to use kite balloons for sport or trade purposes in precisely the same way, the kite balloons being towed to and fro by local vessels. The proposed aircraft liner would therefore not be in economic competition with the airship liner, but the two types would mutually assist each other to find out and develop paying trade connections.

TABLE III.

Type.	Dimensions Spread. Length.	Dimensions Spread. Span.	Dimensions Folded. Length.	Dimensions Folded. Span.	Weight, Light.	Load, ex Fuel.	Maximum Speed.	Endurance (Approx.)
Military Machines.	Ft. in.	Ft. in.	Ft. in.	Ft. in.	Lbs.	Lbs.	M.P.H.	Hours.
Torpedo Carrier (Sopwith Cuckoo) ..	28 4	46 8	28 4	16 9	2,160	1,280	97	8½
Parnall Panther	25 0	29 5	14 6	29 5	1,328	726	108	4½
Nieuport Night Hawk	19 6	28 3	10 6	28 3	1,552	398	139	1½
Flycatcher	23 1	29 0	Non Folder		1,980	509	133	3½
Bison	37 0	46 0	37 0	17 6	3,700	1,256	108	3
Commercial Machines.								
Bristol 10-seater	41 8	54 3	Non Folder		4,427	1,788	115	4½
D.H.34 6-seater	41 3	51 5	Non Folder		4,453	1,620	111	3½
D.H.9.C. 3-seater	30 10	42 5	Non Folder		2,456	800	110	5

the vessel. On a yachting expedition to Norwegian fiords such a ship with a squad of machines for this purpose would prove a great attraction. In addition relatively slow machines of various types might be found to be very economical if the route is such that only short trips away from the ship with passengers, mails, or baggage are necessary.

Passenger Accommodation.

The height between decks generally is made the same as in warships, being about 7 ft. 6 in. instead of the greater heights generally allowed in liners, with exception of the boat deck, where a 'tween deck height of 10 ft. is provided. Portions of the saloons extend through two decks, as usual, and in these portions the height is 15 ft. When preparing detailed designs of a ship for a selected or particular service, these heights would need adjustment, and the total depth of a vessel would probably be increased to some extent.

Subject to the foregoing remarks, accommodation can be found for about 1,250 passengers, besides 450 or more officers and men in ship's company as follows :—

Passengers.		*Ship's Company.*	
In suites	15	Deck officers	8
First class ...	486	Deck hands	60
Second class ...	314	Engineer officers ...	20
Third class ...	458	Engine-room hands ...	70
		Doctor	1
		Purser	1
		Stewards, cooks, &c. ...	280
		Aircraft pilots, mechanics, &c.	20
Total ...	1,273		460

Dimensions of Vessel.

The dimensions of the vessel, and her speed, would vary very considerably according to the particular route on which the vessel would ply, but the scheme has been outlined for what may be termed a moderate-sized vessel for the Atlantic trade, or a full-sized vessel for the Far Eastern services. It is, however, clear that, provided the machinery arrangements can be accepted, the other qualities and conditions can be realised. Particulars are given in Table IV.

Advantages of Proposed Type of Vessel.

Should these proposals be found acceptable and commercially practicable, they will not only expedite the present mail and passenger services, but will offer facilities for rapid communication with ports or inland localities which have hitherto been very badly served by offshoots from the regular passenger and mail services. For instance :—

(*a*) Vessels running on such a service from Great Britain to New York could send off aeroplanes which would reach Montreal before the steamer could get to New York. A corresponding gain would be made by Canadian steamers using the port of Halifax ; on approaching Halifax the aeroplane could depart before the steamer reached the port, and *vice versa*.

(*b*) Vessels running from Great Britain to Australia. These vessels could run to Port Said without a stop,

TABLE IV.

Principal Particulars of Proposed Vessel.

Length between perpendiculars ...	600 ft.
Length over all	670 ft.
Length of flying deck	565 ft.
Breadth over bulge	92 ft.
Breadth at water-line	80 ft.
Breadth at flying deck	100 ft.
Extreme depth to flying deck ...	65 ft.
Depth keel to strength deck ...	55 ft.
Mean draught when crossing Atlantic (about)	26 ft.
Displacement at 26 ft. draught ...	22,000 tons
Horse-power on trial	40,000 to 45,000
Trial speed at 26-ft. draught ...	24 knots
Maximum load draught	28 ft.
Mean horse-power on voyage ...	30,000
Average sea speed	21–22 knots
Fuel capacity	2,500 tons
Cargo capacity (weight)	1,500 tons
Forward hangar (No. 1)	161,000 cub. ft.
After hangar (No. 2)...	117,000 cub. ft.
Forward baggage hold	78,000 cub. ft.
Aft baggage hold	27,000 cub. ft.
Passengers (about)	1,250
Crew (about)	460

The design described in this paper was worked out in the first instance, and primarily, for a steamship serving as an aircraft carrier. The work has been completed on this basis, but it is considered that the resulting arrangements challenge very seriously those which have been adopted in the great majority of liners for the last 30 years.

On the usual plan the midship part of the ship is very largely taken up with funnels, uptakes, cowls, ventilating trunks, engine-room castings, &c. In the new arrangements these things are not to be found in the middle of the ship.

The whole of the steam machinery is placed well aft ; enormous clear decks are provided for passenger accommodation, and all the serious troubles due to overheating of passenger accommodation by the steam machinery are avoided. As electric cooking is proposed, there need be no fires or steam appliances forward or amidships except where steam appliances are fitted expressly for heating purposes.

When designed purely as an ordinary passenger liner, it would be necessary to increase the depth two or three feet, and to modify the watertight subdivision to conform clearly to the latest regulations. The boats, cable gear, and some other details would also have to be rearranged on more usual commercial lines. All such changes could be adopted without giving up any of the essential proposals as to machinery and decks.

Summarising, it may be hoped that the scheme, if developed to a practicable issue, will tend to knit the Empire more closely together, will greatly facilitate rapid communication, and will provide a means whereby the energy and enterprise of British business men may set up a commercial air service of very large dimensions and gradually increasing capacity, and so improve such services as to maintain a lead in the air services for all parts of the world, corresponding to the traditional lead of the British mercantile marine in commercial affairs.

THE BOILER PROBLEM.

To the Editor of Engineering.

Sir,—The "Scotch" boiler has many advocates among practical men, able and willing to defend it against all comers for all-round good behaviour. Therefore, Mr. Kermode's appeal, in his letter published on page 710 of Engineering, of December 8 last, to the makers of such boilers to co-operate in the work of upholding its reputation for good service is surely worthy of their support.

Have the makers ever been induced to regard the subject of thermal efficiency as important ? Evidently, from their point of view the problem is, and has been, one of safety from first to last. How they fulfil every item in the programme set before them is attested by the absence of recorded structural failures while in service, attributable to faulty workmanship of the boiler-maker.

The effect of Government supervision as well as that of insurance and other corporations, is always tending to produce an ideal "non-bustible" boiler. None of the rules and regulations in actual use governing boiler construction includes any pretensions to determine economical furnace dimensions or arrangements.

Whether there are to be four furnaces of, say, 3 ft. diameter, or three furnaces of 4 ft. diameter, the demands of any one of the various schemes of rules and regulations as to the non-bursting qualifications will be faithfully observed in either case, and we shall have a representative of the marine cylindrical return-tube boiler with internal furnaces and combustion chambers, a veritable triumph of applied metallurgical science, showing a skill in workmanship only to be acquired in some of its details by lifelong application.

Yet the fuel cost per unit weight of steam with any system of burning and with any fuel will not be the same in both examples of above furnace arrangements, and it might be as unreasonable to blame the boiler-maker for this difference as to hold him culpable for the unproductive cost of the water space in the fire-box of a locomotive boiler.

With a view to relieving the pressure on a possible scapegoat, I beg permission to propose the following :—

(1) What is a furnace ?—its functions ?

(2) Which part of a modern cylindrical return-tube boiler with internal furnaces and combustion chambers, single or double-ended may be (consistently with answer to No. 1) called the furnace ?

Yours faithfully,

Thomas Le Gall.

Ministerio da Agricultura, Industria e Commercio, Rio de Janeiro, February 16, 1923.

The Shipping, Engineering and Machinery Exhibition.—This exhibition, which is to be held at Olympia from August 31 to September 22 next, will have the advantage of the enlarged building, so that an even more complete display than in the past, of engineering and shipping exhibits, will be possible. Motor boats and internal-combustion engines will this year form an important item, but will not rob any of the space available for other classes of engineering display. As in the past, the leading technical institutions will pay official visits to the Exhibition.

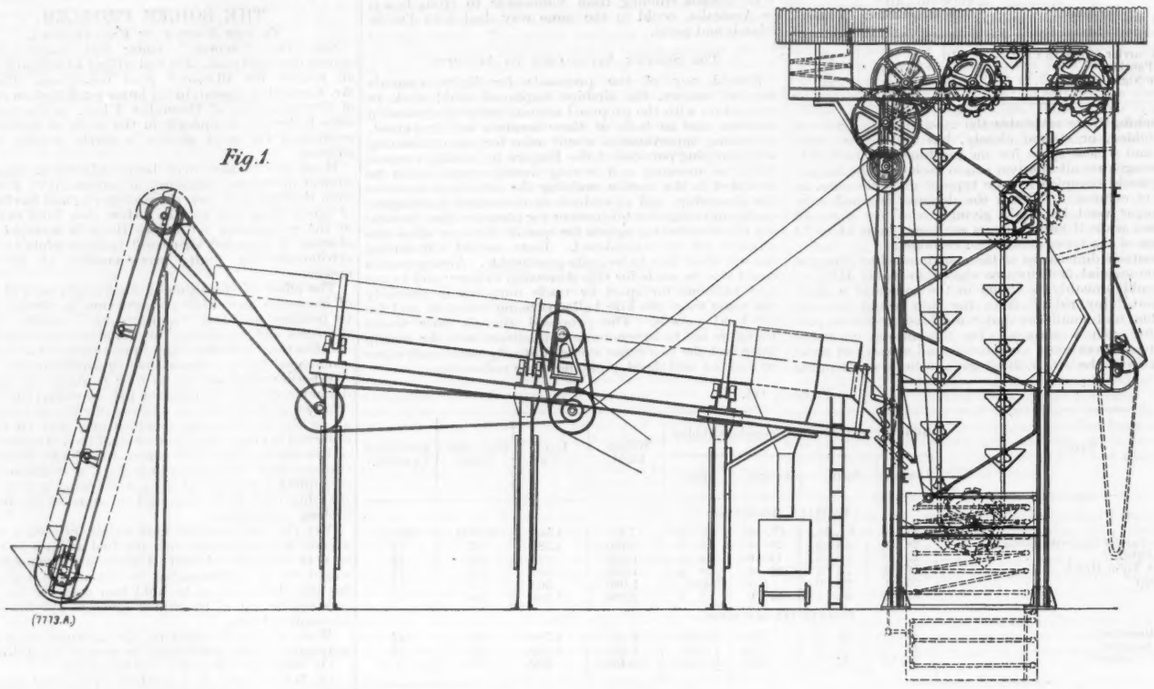
Contracts.—The Manchester Corporation have placed a Contract with Messrs. J. Blakeborough and Sons, Limited, for the supply of the self-closing valves, &c., for the N. and S. Wells for the 4th pipe line from Lake Thirlmere to Manchester. This contract completes the valve equipment required for this line, two previous contracts having already been placed with the same firm for the sluice valves, reflux valves, automatic valves and discharge valves and other ironwork. The total value of the contracts amount roughly to 60,000*l*, and this is the first pipe line which is equipped throughout with valves of one maker.

The Institution of Chemical Engineers. The First Corporate Meeting of this Institution was held on ednesday the 14th inst., at the Hotel Cecil, London. The President, Sir Arthur Duckham, pointed out that the Institution was an endeavour to produce chemical engineers and to hall-mark such men, so that their opinions and services may be accepted at their truer value. The principal object, therefore, of the Institution was education. It was hoped that the Institution would get into touch personally with all the great educational forces in the United Kingdom, and persuade universities, colleges and schools to devote a proportion of their work to the ultimate production of chemical engineers. The drafting of courses in chemical engineering was a matter which was occupying the attention of the Council at the present moment. Although the Imperial College of Science and Technology had commenced chemical engineering instruction some 11 or 12 years ago, it had not yet made chemical engineering a primary subject. The Institution would naturally serve as a centre for chemical engineering education generally, and would make the standard of its associateship and membership such as to render it the recognised authority on the subject. It would take care, however, that its work did not affect adversely any other learned Institution : it would, in fact, assist as far as lay in its power all other bodies having cognate interests.

100-TON TAR MACADAM DRYING AND MIXING PLANT.

CONSTRUCTED BY MESSRS. WINGET, LIMITED, ENGINEERS, WARWICK.

Fig. 1.



THE desirability of reducing labour costs and of securing correct proportioning has led to Messrs. Winget, Limited, to turn their attention to the design of a tar-macadam plant which is largely automatic. We had an opportunity last week of inspecting this interesting plant at the maker's works at The Cape, Warwick, and now illustrate it in Figs. 1, above, and Fig. 2, Plate XXIII. The plant as built is said to be capable of turning out 100 tons of tar-macadam per day of 8 hours, and only a driver and a boy are required to attend to the actual operation. Additional labour is, of course, requisite to ensure the supply of metal at the receiving end, and to control the discharge; the latter would probably be attended to by the men in charge of lorries.

The plant consists essentially of an elevator and drying barrel, and automatic dipping gear. Various interesting details are worked into it, as will be clear from our description. As illustrated in Fig. 2, it will be seen to be driven by means of a 15-h.p. portable engine which conveniently supplies steam to heating coils, &c., but it could be satisfactorily worked with an internal combustion engine, or by electricity, in which case certain modifications, of course, would be necessary for heating, and to secure the atomisation of the oil fuel for the drying barrel burner. The main drive is on to a shaft arranged on the framework carrying the drier. From here by means of chains the drive is taken to the head of an elevator which raises, in a series of small buckets, the amount of metal necessary to keep the barrel working at full capacity. The elevator dumps directly into a chute from which the material passes into the barrel. The latter is about 30 ft. long, and is supported by three sets of rollers. It is driven by a large bevel gear ring. Towards the lower end of the barrel the cylinder is perforated with a large number of $\frac{1}{16}$ in. holes. This section is enclosed in a casing terminating below in a funnel and chute. The dust which is dried off the metal in its passage down the barrel is screened out at this point and delivered into a small truck standing on rails at ground level. Cascading in the barrel is secured by a number of staggered angle irons arranged in the interior. The drier is heated as implied above by an oil burner of a capacity sufficient under ordinary circumstances to dry the metal, using a flame which extends only partly up the barrel. If the proportion of moisture is unusually high the burner is adjusted to give a longer flame, and a thoroughly dried discharge is ensured by this means under the widest range of conditions.

The material is treated with tar by being dipped in a tank maintained at a temperature of about 120 deg. F. The means by which this operation is accomplished consist in an endless chain bucket elevator with intermittent motion. This elevator will be seen to the right hand in our illustrations. It is carried and worked in a tower which is normally enclosed by iron sheeting which, however, was not in place at the demonstration or when the view reproduced in Fig. 2 was taken. The drive from the main shaft is taken by belt to a cone pulley in the upper part of the tower, where intermittent gears work the elevator in stages. In these gears the driving wheel has teeth for only about one-third of the periphery, so that during its revolution at a steady speed it drives the second gear wheel for only a part of the time, after which a pause elapses during which no movement is transmitted to the elevator chain. This intermittent motion is useful in two connections. In the first place it enables the buckets to be held in front of the barrel discharge sufficiently long to be loaded with a batch of dried metal, and in the second it gives the material and tar time to drain out of the buckets when they are tipped, after dipping. The movement of the buckets is downwards on the side of the elevator nearest the discharge from the drier. As a bucket comes into position under this discharge a door is opened and it is filled with a quantity of metal. After a definite time the chute door is closed in a manner which will be referred to later, and, the supply having been cut off, the buckets are moved on one stage, a fresh one being brought into the filling position. On the side of the elevator travelling in an upward direction the excess of tar begins to drain away as soon as the bucket leaves the surface level of the liquid in the tank. The buckets are specially constructed so that in draining the tar does not drip on to the next bucket below. To secure this the buckets are vee-shaped and are constructed of stout rectangular wire mesh on suitable framework. With this form of construction capillary action causes the liquid tar to run down the wires in the vertical plane to the point of the vee, where it drips into a small inclined trough fixed immediately below, and accompanying the bucket. This little trough discharges the liquid out to one side of the chain of buckets and back into the tank below. The intermittent action of the elevator gear coupled with the height of the tower, allows ample time for the tar to drain off before the bucket arrives at the tipping gear. This arrangement is of the familiar cam and trip type and need not be further described. As already noted the intermittent movement is again utilised at this stage, to hold the bucket in the tipping position sufficiently long for the metal to discharge completely. On moving, on the bucket passes with the chain over large sprockets at the top of the tower and then again commences its descent to the filling position.

The material dumped from the buckets falls down a chute into a chute-hopper fitted at the lower end with a door operated by a chain and hand wheel. This hopper is of considerable capacity, and will therefore temporarily accommodate the discharge of the buckets in case of any slight delay in bringing up a fresh lorry or cart. A drain is arranged from near the mouth of this hopper, back to the tar tank, to return to the tank any excess of liquid which may pass over from the buckets. The supply of tar in the dipping tank is maintained at the necessary level by a small belt-driven rotary pump. This pump is driven at a suitable speed off the main pulley on the tower. It draws its supply from a tank which is most conveniently, though not necessarily, below ground level, with a view to the easy discharge of the tar supply, if received in barrels. This tank is also kept heated by a steam coil. A heating coil also passes up inside the tower, which, as we have stated, is normally enclosed, so as to maintain the whole of the gear at suitable temperature to facilitate drainage of surplus liquid back to the tank. A heating coil is also arranged for the fuel oil tank, placed at the top of the tower, for the supply for the oil burner of the drier.

The remaining feature of mechanical interest which we still have to detail is the gear for filling the buckets of the dipping elevator. This gear is worked by rods by a cam on one of the shafts at the top of the tower. The operation is twofold. The discharge is absolutely cut-off by a hinged door, and, in addition, the chute is telescoped so as to clear the next descending bucket. When the elevator has progressed another stage and a fresh bucket is in position, the chute is extended again and the door raised to allow metal to pass to the bucket.

In general, material takes about 4 minutes to pass through the plant. Any difference in the degree of wetness of the metal has no effect on the speed of the plant since the length of the flame is adjusted to suit. On the other hand the speed may be varied to suit the temperature and viscosity of the tar. With a low temperature more time is required for saturation, and this automatically gives more time for draining. The amount of tar taken up may be varied by adjusting the temperature of the dipping bath, between about 5 gallons and 11 gallons per ton of metal. The normal amount is about 7 gallons per ton, and with a little attention to the temperature this can be regularly maintained throughout the day.

The plants are designed in semi-portable types of a capacity of 20 tons and 50 tons per diem, while a larger fixed plant of 200 tons capacity has also been worked out on lines similar to the plant we illustrate. This plant we may point out is constructed with a view to facilitate erection. The sections are all of a portable size, and bolts and nuts are used in assembling. It is

HIGH-SPEED WOOD PLANING AND MOULDING MACHINE.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LIMITED, ENGINEERS, NEWARK-ON-TRENT.

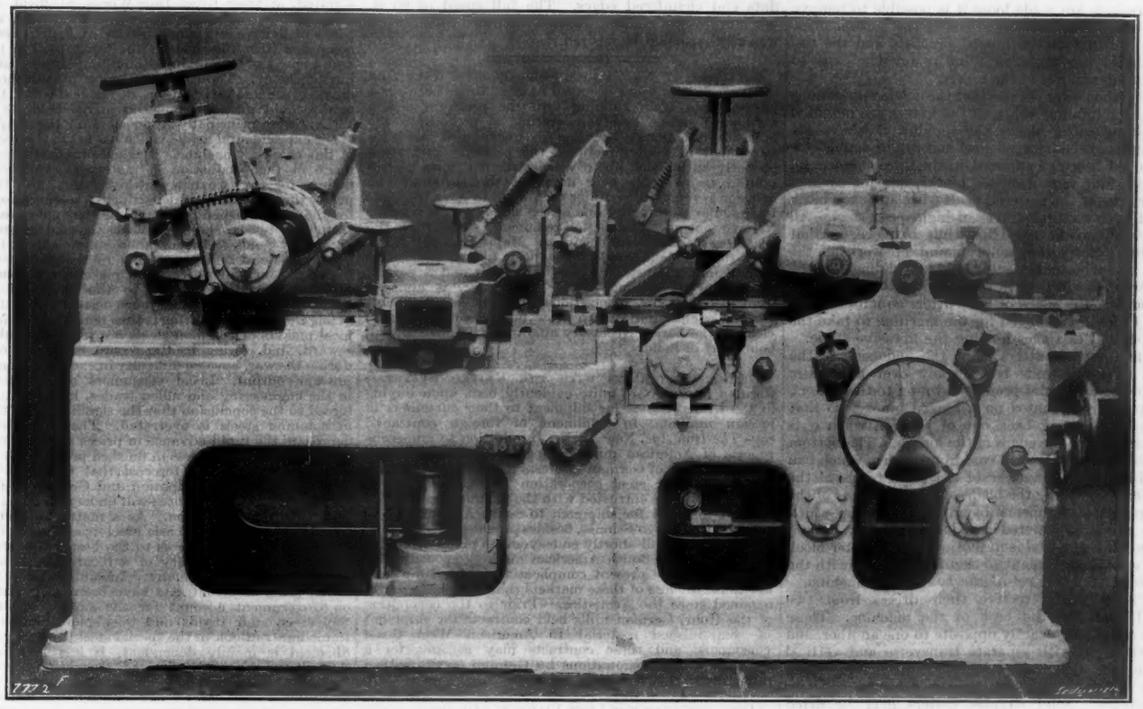
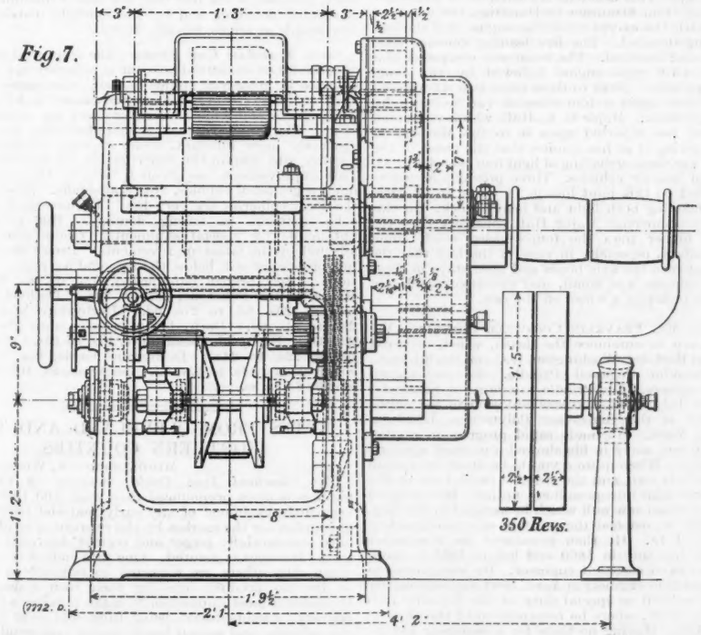


FIG. 6.

Fig. 7.



therefore an easy matter to transfer the whole from one quarry or site to another, and the delay caused by such a move need not occupy any great period of time. The approximate weight of the 100-ton plant is 10 tons.

HIGH-SPEED WOOD PLANING AND MOULDING MACHINES.

THE outstanding characteristic of modern enterprise, the reduction of costs of production by increased speeds of working, is well illustrated by the results attained by the re-design of the well-known planing and moulding machines made by Messrs. A. Ransome and Co., of Newark-on-Trent. A demonstration was given at the works of this firm on Monday last of the working of two newly-introduced machines in these lines. One of these machines is capable of producing tongued and grooved flooring and matchboarding at a speed of 250 ft. per minute, while the other was designed to shape boards to various mouldings at 80 ft. per minute. The demonstration was notably successful, and in the case of the large machine, a speed of 270 ft. per minute was attained. The finished results were highly creditable, both from the standpoint of speed of working and from that of the quality of the completed work. The high-speed planing machine is illustrated in Figs. 1 to 3, on Plate XXIV, and the smaller machine for the production of mouldings is shown on Figs. 4 and 5, on Plate XXV, and Figs. 6 and 7, annexed.

The large machine consists of two parts, a feeding table and the actual machine. The timber is placed on the feeding table which is shown on the right-hand side of the drawings on Plate XXIV. The table is built up on cast-iron trestles and end frames, and in the gaps the top boards there are five sets of rollers with a helix cast on their outer surface. These rolls are supported in end bearings on the side members of the frame and are driven by belts from the shaft of the middle one, which obtains its drive by means of chains from the main machine. The plank against the back board of the table is gripped between the last roll and a cone-ended small roll above which is cast with a rough spiral thread similar to that of the table ones. As these rolls revolve they feed the plank forward to the planing machine. As each piece of timber is fed in, another takes its place and the operations continue. The new boards are placed on the table at the front to fill the gaps as they are made. A guide plate is set at an angle to the axis of the table and at its end to direct the progress of the planks to the feed rolls.

The actual planing machine has a heavy cast-iron base, the table on which the timber is supported being made with a series of renewable cast-iron plates which can easily be removed for trueing up or replacement in case of wear. As the timber to be planed is fed in to the machine it first passes between two pairs of rollers. These are the feed rolls, and the first pair are fluted to give an effective grip upon the timber, while the second pair are plain. The four rolls are driven through toothed wheels in order to ensure the boards being fed continuously without any slip. The drive for the feed rolls is taken through a variable speed gear shown behind the machine in the plan (Fig. 2, Plate XXIV). This variable-speed device consists of two pairs of cones connected by a belt. By drawing the one pair of cones apart, as the other pair are made to approach each other, the effective pulley diameters operating the drive are changed and the speed altered. The variation in speed is continuous, from 32 ft. to the normal highest value of 250 ft. per minute. A handwheel control through a bevel gear makes it possible to change the speed from the operating side of the machine. To ensure that the feeding-in table works at a suitable speed for the planing operations, its drive

is taken from the shaft which transmits the motion to the feed rolls of the planer. The top pair of feed rolls may be raised or lowered together to suit the work on boards of different thicknesses. This is effected through gearing by turning the large hand wheel at the front of the machine. As the frames carrying the top roller brackets are made loose it is possible to remove the top rolls and brackets to get at the bottom ones. All the bearings of the hinged brackets and the top roller shafts are provided with removable caps to facilitate the removal of the rollers.

To keep the power required for the cutting operations down to a minimum value all the knives are mounted on revolving cutter blocks, the spindles of which are made of toughened forged steel and run in double-row ball journal bearings enclosed in dust-proof housings. There are four sets of cutter blocks, one for each of the four sides of the material dealt with, and each block is fitted with six thin knives of high-speed steel. All the cutters may be trued up while in place, so that each does exactly the same amount of work as the others. A carborundum stick held in a sliding carriage is traversed the full width of the cutter block and by just touching the edges of the cutters equalises them. Special slides are arranged for the machine to take the hand-operated carriages holding the abrasive stone.

The first set of cutters plane the underside of the timber. Pressure rolls bear evenly over the entire width of the wood and press it down on to the cutters. These rolls are mounted on a hinged bracket so that they may be swung back out of position when it is necessary to true the edges of the knives. The bottom cutter block is fitted in a cast-iron drawer, which can be readily drawn out clear of the main frame of the machine for changing the blades. The thickness of the cut is regulated by means of an adjustable lip which can be raised or lowered and locked in any desired position while the feed is in motion. The cutter block has a vertical adjustment so that it can be set with the blade edges at the level of the bed of the machine.

The side cutters receive their drives from two vertical shafts in the base of the machine. These cutters are placed exactly opposite to one another, and are both fitted with separate transverse and vertical adjustments. The loaded wheels shown beside these cutters are used to apply pressure near the edges of the material. Solid circular cutters may be fitted instead of the expansion cutter heads with six blades, for the work involved in the production of tongued and grooved boards.

The top cutter is mounted on a heavy bridge casting extending across the machine. Its vertical position may be varied at will by means of the hand wheel, and an index pointer and scale provide information regarding the thickness of the finished work. The cutter spindle shown at the end of the machine is for forming circular and V beads on the face side of the matchboarding.

The moulding machine was designed for planing on all four sides and for tonguing and grooving, edging and beading boards up to 7 in. wide and 3½ in. thick, as well as for producing single and double mouldings of any pattern in hard and soft woods. The elevation and plan of this machine are shown in Figs. 4 and 5, on Plate XXV a photograph in Fig. 6, on page 365, shows the general appearance and arrangement. In Fig. 7, on the same page, an end elevation is given.

This machine has a variable-speed mechanism similar to the larger one, but smaller. In this case, however, it is fitted in the bedplate of the machine and operated by a hand wheel at the right-hand end. The rates of feed obtainable range from 20 ft. to 80 ft. per minute, and it is possible to make any desired change while the machine is in operation. At the back of the machine there is a set of spur gear wheels with machine-cut teeth which are used to drive the feed rolls. These consist of two pairs of heavy rolls, the first of which are fluted. As all the rolls receive direct drives the boards are fed continuously without slip. The large hand wheel in front of the machine is used to raise and lower the two top rolls together, but the pressure on them is applied quite independently, so that the front rollers will continue to feed continuously even if a thin board should follow a thicker one. The timber is held down to the table of the machine by spring pressures applied to the ends of small levers on which are mounted hard wooden blocks. The first cutting operation is performed by the bottom cutter block, which carries six thin knives of high-speed steel. This unit is mounted in a cast-iron drawer similar to that used in the large machine. A vertical adjustment by means of a wedge and screw is used to bring the cutters into action. The knives are trued up or "jointed" as it is termed, in exactly the same manner as in the planing machine. The side cutter blocks are of square section and set out of line with each other, and are provided with separate transverse and vertical adjustments. The surrounding hoods not only act as guards, but also as conveyors for the chips, and the one on the front cutter provides a side pressure on the material. The top cutter at the end of the machine has a cutter block of square section which can be canted to suit bevel moulding work. All the spindles of the blocks run in double-row ball bearings enclosed in dust-proof cases. In the demonstration this machine was used to produce a double curved moulding, with three narrow flats and chamfered edges. The full speed of 80 ft. per minute was maintained and the finish of the work was all that could be desired.

COLLISION AT NEW CROSS.—Shortly after 6 a.m. on January 6, a collision occurred at New Cross between a Metropolitan train running into the platform and a stationary engine and van waiting to proceed in the opposite direction. The line in question is used for movement in both directions, the platform line being properly an up line, on to which arriving down Metropolitan trains cross over north of the station. The collision is reported by Major G. L. Hall to have been due to irregular working by one of the signalmen, who seems to have sent an "obstruction removed" signal while the platform road was still occupied. Major Hall points out that the accident would have been almost impossible with a modern installation of circuiting and a correct disposition of locking bars. The latter, it appears, were installed, but in positions which made it possible for the engine and van to draw up close to the signal clear of the bars. Necessary alterations are, it is stated, being put in hand.

GERMAN CONTRACTS WITH THE UNITED STATES.—German interests are quite evidently bent upon buying in the United States for shipment to their customers in foreign markets, in fulfilment of foreign contracts, says *The Iron Age*, New York. In addition to numerous reports of American mills having been approached by representatives of German interests in the United States, one large Ruhr steel corporation has two agents in America, who are entrusted with the placing of orders for finished material for shipment to South America. It is believed that Hugo Stinnes, besides purchasing coal in the United States, will shortly endeavour to place orders for steel to ship to South American markets on contracts, in order that the present complication in the Ruhr shall not cause the loss of these markets that have been partly regained since the Armistice. Prior to the occupation of the Ruhr, German mills held contracts for shipment of semi-finished material to American West Coast consumers, and these contracts may account for a recent report of negotiations by German agents with a mill whose product is semi-finished steel.

DERAILMENT ON THE CREE VIADUCT. On December 28 last, a derailment occurred on the Cree Viaduct near Palnure Station on the Portpatrick and Wigtownshire Joint Railway. This accident occurred to a passenger train running from Stranraer to Dumfries, the whole of the train, with the exception of the engine and the last vehicle being derailed. The five leading vehicles were overturned and wrecked. The train was composed of a Caledonian 4-4-0 type engine followed by two four-wheeled meat vans. Next to these came two six-wheeled vans, and then again a four-wheeled van followed by heavier bogie stock. Major G. L. Hall, who investigated the accident, has reported upon it to the Ministry of Transport, giving it as his opinion that the cause of the derailment was the marshalling of light four-wheeled stock in a train of heavier vehicles. Three previous accidents have occurred on this joint line in 11 years, in all cases to trains including both light and heavy stock. In this most recent occurrence Major Hall considers that the speed was higher than the four-wheeled stock could take with safety, especially in view of the fact that the clearance between the axle boxes and horn stays in these particular vehicles was small, and excessive oscillation might result in lifting a wheel off the rail.

THE LATE MR. FRANKLIN COGSWELL PRINDLE.—We regret to have to announce the death, which occurred at the Naval Hospital, Washington, D.C., on the 6th inst., of Mr. Franklin Cogswell Prindle, the well-known American engineer. Mr. Prindle was born at Sandgate, Vermont, in July, 1841, and was educated in the public schools, and at the Rensselaer Polytechnic Institute, Tring, New York. He made rapid progress in mathematics, and very early in life showed a marked aptitude for mechanics. When quite a youth, he fitted up a small workshop of his own, and the work he carried out in this room brought him into prominent notice. He accepted a berth in a steam saw mill which he assisted in erecting, and in which he reached the position of superintendent at the age of 18. He then re-entered the Rensselaer Polytechnic Institute in 1860 and left in 1861 to enter the navy as third assistant engineer. He was promoted to second assistant engineer in April, 1863, and was shortly afterwards ordered to special duty at the Novelty Iron Works, New York, where he remained until the close of the Civil War. Having no taste for a seafaring life, he tendered his resignation which was accepted in September, 1865. About two years later Mr. Prindle was offered and accepted the appointment of assistant civil engineer at the New York Navy Yard; he was shortly afterwards transferred to the Navy Yard, Philadelphia, in charge of works of improvement. During his active service he was greatly interested in the advancement of his corps as an important branch of the navy and in securing suitable recognition of its proper position. He was engineer and secretary of the American Dredging Company, Philadelphia, in 1876-77, also engineer and superintendent of other companies, and member of a number of learned societies. The burial of Mr. Prindle, who was transferred to the retired list in February, 1901, with the rank of Rear-Admiral, took place with military honours at Arlington National Cemetery, on the 9th inst.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The outstanding news of the week is that of the War Office contract for 20 light tanks, at an approximate cost of 120,000*l.*, or about 6,000*l.* per tank. The bulk of the work is to be done by Messrs. Vickers, Limited, at their River Don Works, Sheffield, and the remainder at the same firm's works at Erith. The new tanks will have an endurance of at least 1,000 miles, compared with 150 miles of the tanks used in the war, and a speed of 25 m.p.h. without impairing their working efficiency. Though the placing of this order has created general satisfaction, it was expected that the work would mainly be placed in Sheffield, as Messrs. Vickers were principally responsible for the construction of the experimental model which has led to the acceptance of this new war machine. Marked progress is now being made in the production of materials, armaments and fittings for the two new battle cruisers. As the work passes through the basic departments, sections responsible for the more finished operations are beginning to benefit. In the purely commercial branches the contrast in current prosperity tends to become more marked week by week. Common steels and everything in the nature of basic materials, including scrap and pig-iron are consistently on the rise owing mainly to the abnormal demand which has arisen from the French occupation of the Ruhr. While German competition is thus temporarily suspended, local makers of common steels are reaping a substantial reward, and, owing to the record extension of plant during the war, have no difficulty in exceeding the average pre-war output. Local consumers of common steels in the engineering and allied trades, however, are being forced to the conclusion that the significance of the boom in common steels is overrated. They are inclined to deprecate the rapid advance in prices as interfering with the expansion of business in finished products at a steady and reliable rate, and forecast that when the Ruhr is freed from French occupation and German competition is thus restored, local prices will undergo a quick revision in a downward direction. As a matter of fact leading representatives of the basic steel trades have for some time been in conference as to the best action to take to deal with the probability of a recurrence of abnormal competition from Germany. In addition to the tanks order, some nice contracts have been booked this week on Government account for the supply of steel bars, tool steel, stair treads and telephone apparatus. The immediate outlook in the special steel trades, upon which Sheffield is mainly dependent, is less hopeful. It is difficult to gauge the rate of recovery, so erratic are conditions at individual works, and indeed, while in exceptional cases order books show a much healthier state of affairs, the bulk of departments producing high-class machinery and cutting tools are scarcely any better off than they were two or three months ago. In contrast, however, is the fact that the rate of unemployment is steadily declining and for the Sheffield district alone now stands at approximately 30,000.

South Yorkshire Coal Trade.—The improved position of collieries on industrial account is reflected in a general advance in industrial grades of fuel. Compared with a week ago, best steam hards have advanced 1*s.* 6*d.* per ton while slacks and smalls have recorded an average rise of 2*s.* The home demand on manufacturing account is distinctly more buoyant, while exports continue at a healthy rate despite the unsettlement on the Continent. This improvement has given a fillip to the market in inferior grades of cobbles, nuts and smalls. Stocks at all the local collieries are very low. Furnace and foundry coke continue in strong demand. Big prices are obtainable for special shipments. House coal is unaffected by the latest improvements. Prices are steady; but orders are still below the seasonal average. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*, Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire small nuts, 17*s.* to 19*s.*; Yorkshire hards, 22*s.* to 24*s.*; Derbyshire hards, 21*s.* to 23*s.*; rough slacks, 11*s.* to 12*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 6*s.* to 8*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Scarcity of Cleveland pig-iron is more pronounced than ever, and there seems very little likelihood of any early material enlargement of supplies for the market by the re-starting of idle plant until substantially larger and regular deliveries of coke to the furnaces is assured. One firm indeed is damping down, but others are expected to re-kindle a furnace or two to produce iron for their own consumption. It is now almost impossible to make purchases for early delivery, manufacturers being fully sold over the next two months, and second hands having command of very little iron. No. 1 is put at 130*s.*; No. 3 quality, 127*s.* 6*d.*; No. 4 foundry, 125*s.*; and No. 4 forge, 120*s.*, all f.o.t. makers' works, half-a-crown more being asked f.o.b. Tees. Some sellers are asking above the foregoing quotations.

Blast-Furnace Coke.—Continued acute shortness of Durham furnace coke is causing anxiety, but though up to 80*s.* is named for export, contracts are being renewed with local regular customers at 40*s.* for average kinds delivered.

Hematite.—As regards East Coast hematite there are merchants who are in a position to sell fairly considerable parcels, but producers are practically off the market, having filled their books up to June. Values continue to steadily advance, but are still cheap as compared with

figures obtainable for Cleveland pig-iron. Mixed Nos. of hematite have been sold at 125*s.* both for home purposes and for shipment overseas, but rather more has also been paid, and sellers are not now readily found at the price named.

Foreign Ore.—Business in foreign ore is little heard of. Consumers having considerable stocks, and being well bought, are off the market. Offers to sell best rubio at 24*s.* 9*d.* c.i.f. Tees fail to tempt users.

Ironstone Miners' Hours.—The Officials, and executive of the Cleveland Ironstone Miners' Association, in view of the serious situation in the ironstone mining industry, have intimated that they feel compelled to reconsider the situation as regards the question of hours. The suggestion of the owners that the employees should revert to an 8-hours' day was, on a ballot of the miners, rejected by a small majority. The owners have stated that certain mines could be opened in the very near future if terms could be arranged on the question of hours.

Manufactured Iron and Steel.—Finished iron and steel producers have good order books, and large inquiries are still circulating, but a feeling is growing that further rise in values will check buying. Common iron bars are 12*l.*; iron rivets, 14*l.*; black sheets, 15*l.*; soft steel billets, 10*l.*; hard steel billets, 10*l.* 5*s.*; packing (parallel), 8*l* 10*s.*; packing (tapered), 11*l.* 10*s.*; heavy steel rails, 10*l.* 10*s.*; fish plates, 14*l.* 10*s.*; and galvanised corrugated sheets, 19*l.* 10*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—The scarcity of free supplies of coal has been aggravated by a stoppage of some 17,000 colliery workers over the non-unionist question. Prior to this strike, which commenced on Monday, buyers experienced much difficulty in obtaining even small parcels and now it is practically impossible to secure supplies for shipment this side of the holidays. Nominally sellers ask 40*s.* for best large coal and 30*s.* for best smalls, while 32*s.* 6*d.* has been paid for large for shipment over the remainder of the year and 22*s.* 6*d.* for ordinary quality smalls. Meanwhile the docks are congested with shipping, and it is inevitable that many boats will be held up over the holidays. The employers and the coal trimmers and tippers have failed to reach an agreement in respect to the working of a third shift, and the matter is now to go before a Court of Inquiry. The demand is as keen as ever. The Germans are stated to have placed c.i.f. orders for about 300,000 tons of coal for delivery between now and the end of August, while the Russians are in the market for about 250,000 tons for shipment between May and August. Exports of coal as cargo last week amounted to 659,700 tons, the largest quantity despatched in any week of the year to date. Of this total no less than 400,000 tons went to France and Italy, of which 293,000 tons went to the former country and 105,200 tons to the latter. Exports to South America totalled 54,400 tons, to Spain 28,300 tons, to Portugal 22,300 tons, 29,600 tons to British coaling depôts, 14,900 tons to the United States, and 112,000 tons to other countries, of which 44,000 tons went to Germany and 20,000 tons to Belgium.

Iron and Steel Trades.—In view of the continued advance in the price of raw materials, particularly scrap and pig-iron, the Welsh steel and tinplate trades are unsettled. Tin-plate bars are offered at several shillings above the minimum of 8*l.* 16*s.*, and it is expected that there will be a substantial advance in the minimum. Tin plates are steady at 24*s.* to 24*s.* 6*d.*, and there is a good Continental demand. Shipments of tin plates and terne plates last week amounted to 7,700 tons, compared with 4,972 tons in the previous week, black plates and sheets to 1,905 tons against 1,131 tons, galvanised sheets to 4,813 tons against 169 tons, and other iron and steel goods to 4,548 tons against 428 tons.

New Steamers for Cardiff.—The Bristol Channel Steamers, Limited, have purchased from Lloyd Royal Belge (Great Britain), Limited, the steamers Normandier (7,100 tons deadweight) and the Scaldier (6,100 tons deadweight). Both vessels are reconditioning at Antwerp and will be delivered to the buyers at a total of cost of 32,000*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—A moderate amount of activity is fairly general throughout the local steel industry and conditions at the various works are getting better. The demand for ship plates is still slow, but a marked improvement has taken place in the demand for sectional material both on home and export account. Inquiries indicate more readiness on the part of buyers to again enter the market. Black steel sheets are moving freely and orders now on hand amount to quite a respectable tonnage. Most of these are for the lighter gauges for export, but home buyers have also been placing fairly good orders recently. Prices all round are very firm and have a hardening tendency. To-day's quotations are as follow:—Boiler plates, 13*l.* per ton; ship plates, 9*l.* 15*s.* per ton; angles, 9*l.* 5*s.* per ton; and sheets, 12*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—A steady and increasing business is being done in Scottish pig-iron at present, and a fairly respectable tonnage is going foreign. Buying has gradually got better and order books are very well filled up. The local steelmakers are accounting for the output of hematite, and some consideration is being given to increasing the production. Foundry iron is moving freely, and no stocks are held as the demand for supplies is expanding almost daily. Prices are very strong, and all dealings are the subject of negotiation. The current quotations are as follow:—Hematite, 6*l.* 7*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* per ton, and No. 3, 6*l.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, March 17, amounted to 2,915 tons. Of that total, 2,662 tons went foreign and 253 tons coastwise. For the corresponding week last year the figures were 876 tons foreign and 93 tons coastwise, a total of 969 tons.

Shipbuilding.—There is little movement in the shipbuilding industry at the present time, due in large measure to the high cost of construction and owners are keeping out of the market. One or two contracts for new tonnage have been fixed up lately, but little improvement in bookings can be expected until prices become easier and general conditions get better. On Saturday last a function of no little interest took place at the yard of Messrs. Scott's Shipbuilding and Engineering Company, Greenock, when the twin-screw geared turbine steamer Patroclus was launched. This new vessel is for the Blue Funnel Line—Messrs. Alfred Holt and Co., Liverpool—and is of 11,400 tons, 8,000 h.p., 517 ft. in length, 62 ft. in breadth, and 39 ft. in depth. The Patroclus is one of four steamers which will maintain a regular monthly sailing between Glasgow, Birkenhead and China, and she will be able to carry about 140 first-class passengers. A notable and interesting feature in connection with this launch is that the new vessel is the 66th steamer built by Messrs. Scott, of Greenock, for Messrs. Alfred Holt and Co., of Liverpool, within the past sixty-six years. The first vessel was the steamer Zulu, of 278 tons and 60 h.p., built in 1857, and the difference in size and equipment between the two vessels named is indeed very great, and shows the development which has taken place in the intervening years. Immediately after the new vessel vacated her berth the keel plates of her sister ship were laid down.

SALT AS A COAL-DUST MOISTENER.—Tests are being conducted at the experimental mine of the Bureau of Mines, Bruceton, Pa., for the purpose of determining the value of salt in conducting moisture to dry coal dust.

ADMIRALTY GUN-MOUNTING OVERSEER AT BARROW.—We learn that Engineer Captain Harry H. Johnson, D.S.O., has been appointed Overseer of gun-mountings for the Admiralty at Messrs. Vickers' works at Barrow-in-Furness, in succession to Engineer Captain John D. Wilson, whose period of two years has expired. In this capacity Captain Johnson will be responsible for supervising the manufacture of the gun-mountings for the new capital ships.

MARINE INTERNAL-COMBUSTION ENGINES.—The engines for the ocean-going passenger steamer which Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, are building for Mr. Dan Brostrom, of Gothenburg, are being constructed by Messrs. Burmeister and Wain, of Copenhagen. They are to be double-acting and work on the four stroke cycle, while each cylinder will develop about 1,000 h.p. The total power of the twin-screw installation will be about 13,500 h.p., and will propel the vessel of 17,000 gross tonnage at a speed of 17 knots.

OIL CANS WITH SELF-CONTAINED FILTERS.—In order to prevent the spouts of their oil cans becoming choked by cotton waste or other material which may find its way into the interior of the can, Messrs. Joseph Kaye and Sons, Limited, of Lock Works, Leeds, fit an internal filtering device, through which the oil has to flow before it passes through the valve at the base of the spout. The filtering apparatus consists of a perforated tin cylinder surrounding the inlet to the valve, and is, we understand, only employed by Messrs. Kaye, who are well known makers of oil cans of various kinds.

COOMBE MEMORIAL SCHOLARSHIP.—This scholarship, which will be of the annual value of 60*l.* a year and will be tenable in the Faculty of Engineering of the University of Bristol, will be offered for competition for the first time this year. It has been established by the Engineering and the National Employers' Federations (West of England Association) as a memorial to a former president, and will be open to candidates who habitually reside within the area of the association, which includes the Counties of Gloucester, Somerset, Wilts., Devon and Cornwall, as well as the City of Worcester and the towns of Hanley Castle, Malvern, Malvern Wells, Pershore and Newport, Mon. The examination will be held at the Merchant Venturers' Technical College on Wednesday, July 4 next, and applications must be sent to Mr. A. Storey, director of the association, not later than July 1.

BALL BEARING DRAWING INSTRUMENTS.—Messrs. Norton and Gregory, Limited, of Castle-lane, Westminster, S.W. 1, have sent us some particulars of a new series of drawing instruments such as compasses and dividers in which a ball bearing is incorporatad in the joint. The balls fit loosely in holes in a disc, which forms a cage, and run on hardened steel races sunk in recesses in the electrum side pieces, the parts being clamped together by a bolt of the usual design. With this arrangement the thrust and wear are taken entirely on hardened steel surfaces, so that wear is practically eliminated. It is also claimed that the movement is perfectly smooth at all points and that the adjustment is extremely delicate and simple. We understand that instruments of this design are now in course of production at the firm's London factory and that they will be ready for delivery in quantities early in June next.

NOTICES OF MEETINGS.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, March 23, at 7.30 p.m., in the Mappin Hall of the University, St. George's-square. Paper on "Further Notes on Britannia Metal," by Captain F. Orme, M.Met.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 23, at 7.30 p.m., at 39, Victoria-street. Lecturette, "The History and Development of the Underground Railway," by Mr. R. J. Siddall (Member).

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, March 23, at 7.30 p.m., at the Engineers' Club, Coventry-street, London, when Mr. Axel Wickman, of Messrs. Alfred Herbert, Limited, Coventry, will deliver a paper dealing with "Modern Gauging Systems" to be illustrated by lantern slides.

THE INSTITUTION OF ENGINEERING INSPECTION.—Friday, March 23, at 7.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Annual Meeting. Paper by Mr. Kyrle W. Willans, on "The Future of Steam as Applied to Motor Vehicles and Agricultural Engines."

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, March 27, at 8 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, London, when a paper on "Window Design and the Measurement and Predetermination of Daylight Illumination," will be read by Mr. P. J. Waldram, F.S.I., and Mr. J. M. Waldram, B.Sc.

CARDIFF AS A MANUFACTURING CENTRE.—The Cardiff Development Department, City Hall, Cardiff, has issued a pamphlet pointing out that from the point of view of cheap power, plentiful water supply and ample transport facilities, that city has claims which invite the careful consideration of manufacturers. Firms interested can obtain a copy from the above address.

INSTITUTION OF ELECTRICAL ENGINEERS.—Out of the balance of the War Memorial Fund it has been decided to establish two scholarships, each of the value of 50*l.* per annum and tenable for three years, to provide for the education of children of members who were killed or permanently disabled in the late war. Applications giving full particulars as to general and financial circumstances, should be addressed to the Secretary of the Institution, Savoy-place, Victoria Embankment, W.C. 2.

NEWFOUNDLAND ORE FOR GERMANY.—The statement that the Stinnes contract with the British Empire Steel Corporation, for iron ore from the Wabana mines, Newfoundland, for export to Germany had been cancelled in consequence of the Ruhr occupation is denied by a member of the Board of the corporation, according to *Iron Trade Review*, Cleveland, Ohio. It is anticipated that shipments will be resumed on May 1, as the corporation has received no word to the contrary from Germany.

NETHERLANDS INTERNATIONAL GAS EXHIBITION.—In connection with the International Gas Exhibition which the Municipal Authorities of Amsterdam are organising, to be held in that city from October 13 to November 11, 1923, H.M. Consul-General at Amsterdam has forwarded to the Department of Overseas Trade a number of copies of the rules and regulations of the exhibition, together with forms of application for space. British firms interested may inspect the rules, &c., on application to the Department of Overseas Trade (Enquiry Room), 35, Old Queen-street, Westminster, London, S.W.1. A few copies are available for loan to firms which may be unable to arrange for an inspection in London.

SUMMER MEETING OF THE INSTITUTION OF ELECTRICAL ENGINEERS.—This meeting is to be held this year at the North Western centre of the Institution, the proceedings opening at 10 a.m. on Tuesday, June 5, at Manchester. It will be continued the following day in the same city and on Thursday, June 7, the meeting will be continued at Liverpool. The final day, Friday, the 8th inst., will be spent in North Wales with Llandudno as headquarters. A large number of works are to be visited during the meeting, and receptions are to be held by the Lord Mayor and Corporation of Manchester, the University of Manchester, the Lord Mayor of Liverpool and the London Midland and Scottish Railway Company. Those proposing to attend the meeting should return their reply form to the Secretary of the Institution by March 28th.

ALLOYS RESISTANCE TO CORROSION.—A symposium and general discussion on this subject will be held at the Department of Applied Science, the University, Sheffield, on Friday, April 13, beginning at 3 p.m. The meeting is being organised jointly by the Faraday Society, the Sheffield section of the Institute of Metals and the Manchester Metallurgical Society. The scope of the discussion will include the new non-corrodible non-ferrous alloys such as stainless nickel silver and the nickel chromium alloys as well as stainless iron and steel. A general introduction to the discussion will be given by Professor C. H. Desch, F.R.S., and numerous contributions of interest are expected. Further particulars may be obtained from Mr. G. R. Bolsover, Brown Firth Research Laboratory, Princess Street, Sheffield, or from the Secretary of the Faraday Society, 10, Essex Street, Strand, London, W.C.2.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

MR. R. A. CHATTOCK, M.I.E.E., CITY ELECTRICAL ENGINEER.

(*For Description, see Page* 353.)

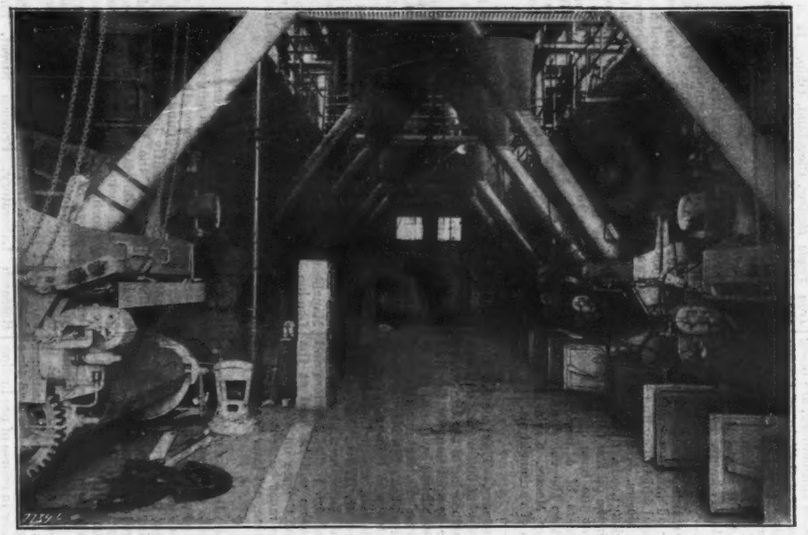


FIG. 82. BOILER-HOUSE BAY, LOOKING TOWARDS TURBINE-ROOM.

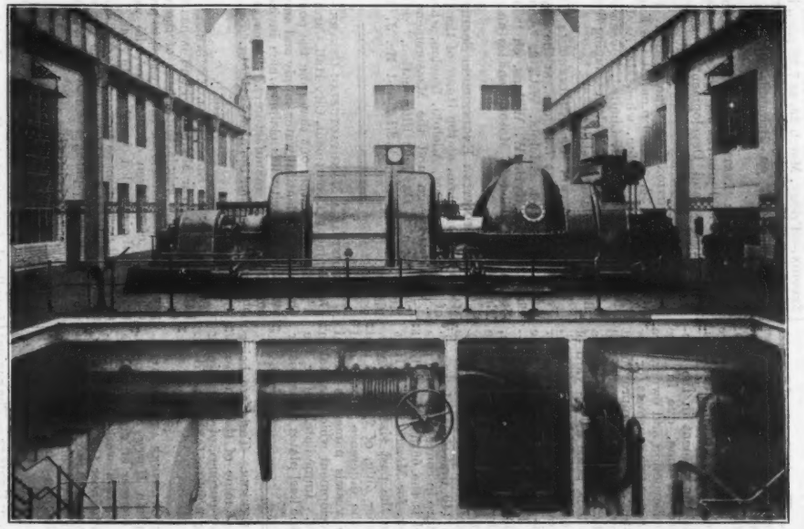


FIG. 83. NO. 1 TURBO-ALTERNATOR SET, LOOKING TOWARDS SWITCH-HOUSE.

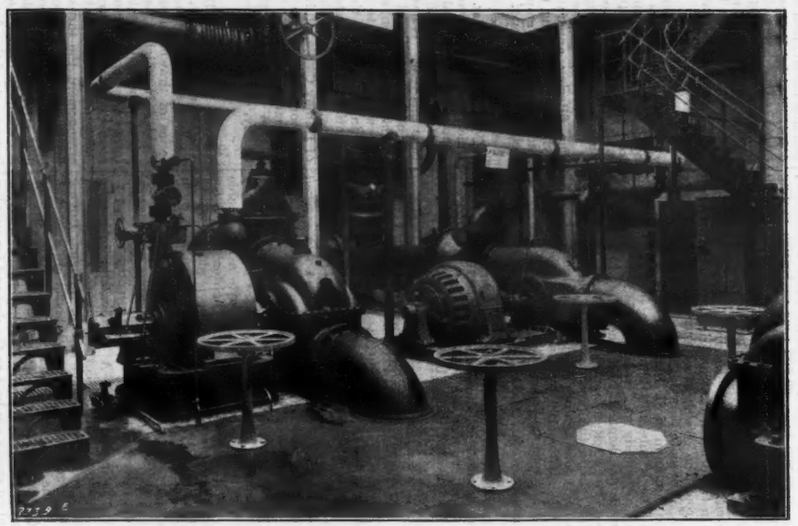


FIG. 84. CONDENSING PLANT FOR ONE TURBO-ALTERNATOR.

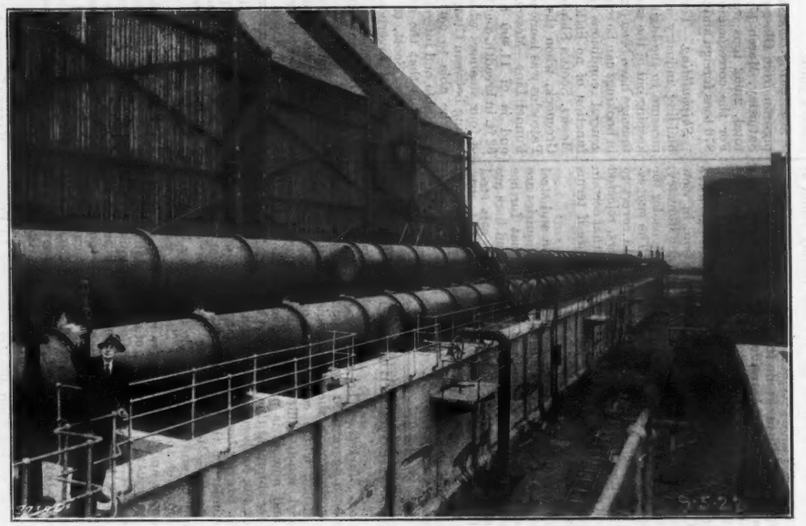


FIG. 85. COOLING TOWERS AND CIRCULATING WATER DISCHARGE MAINS.

100-TON TAR MACADAM DRYING AND MIXING PLANT.

CONSTRUCTED BY MESSRS. WINGET, LIMITED, ENGINEERS, WARWICK.

(*For Description, see Page 364.*)

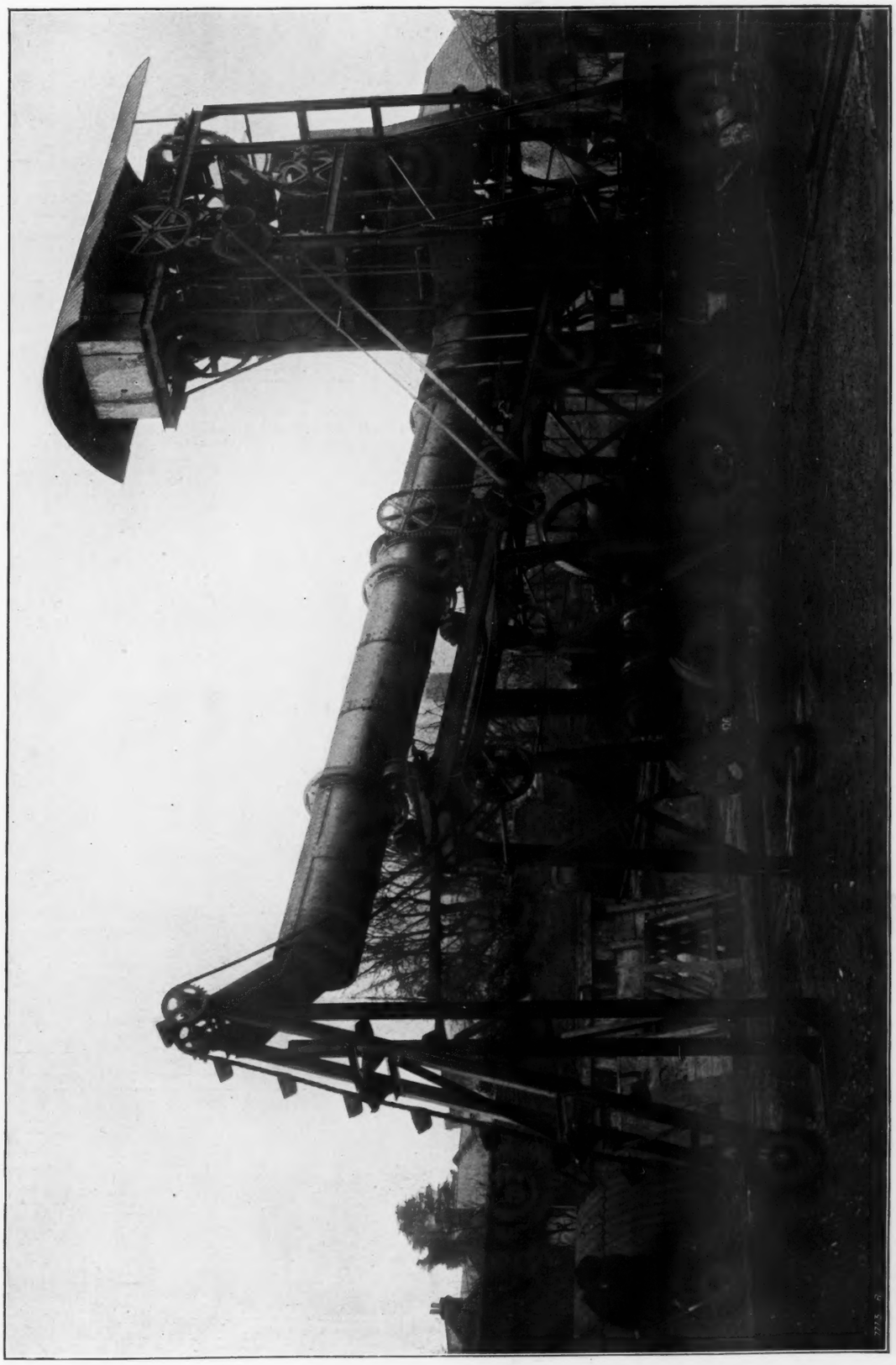


FIG. 2.

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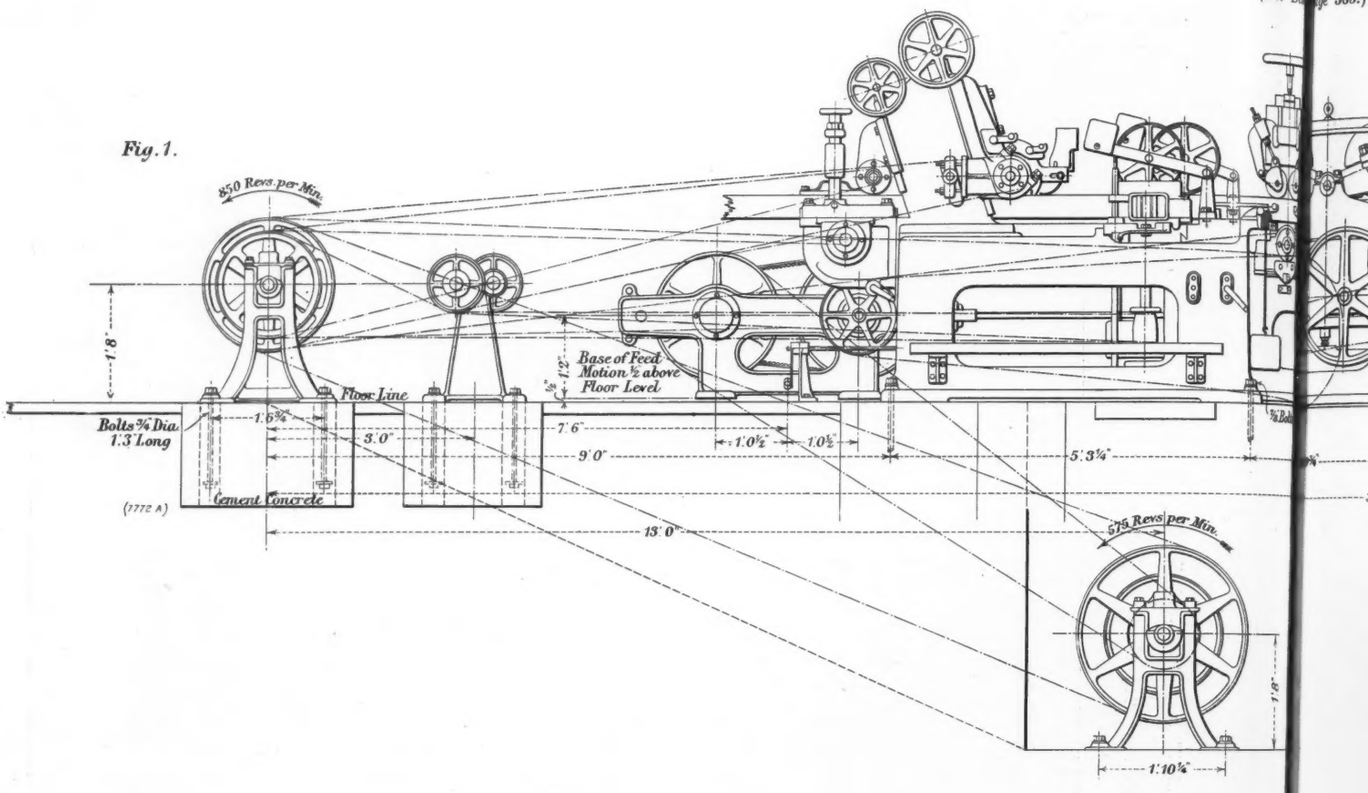
HIGH-SPEED FLOORING AND BOA

CONSTRUCTED BY MESSRS. A. RANSOM LIMITE

(For De ge 365.)

Fig. 1.



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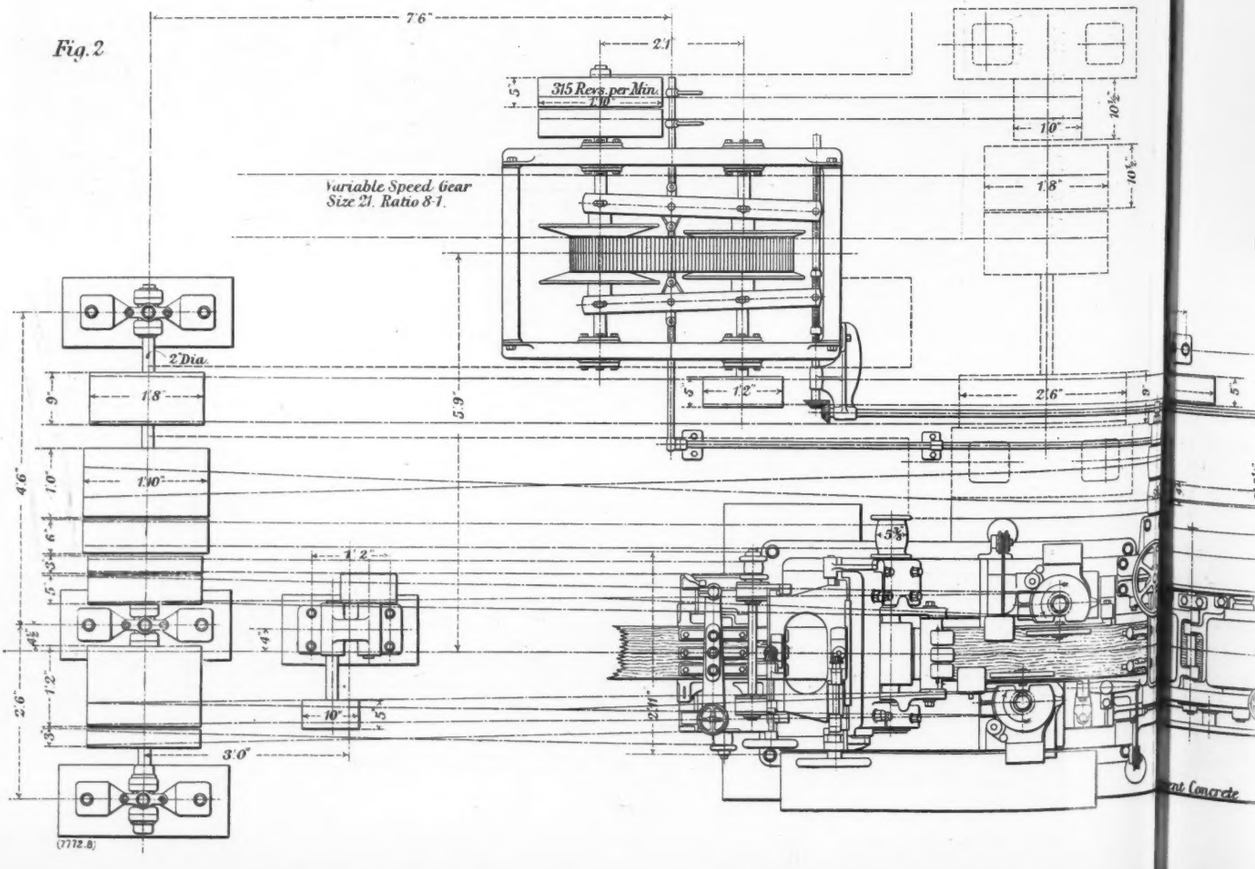
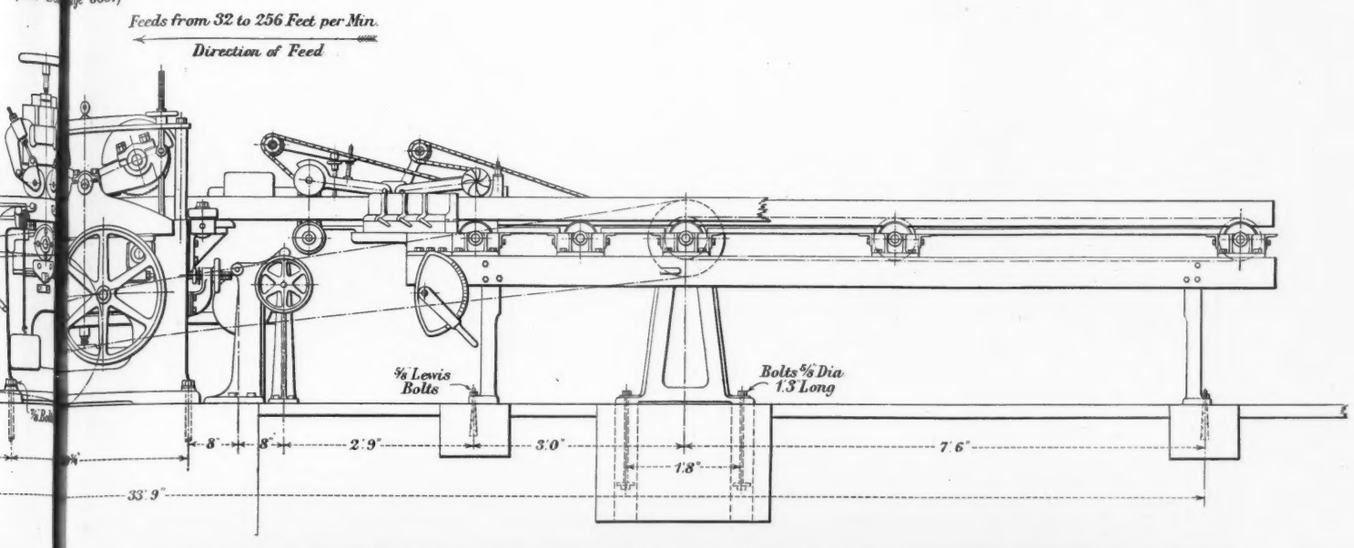
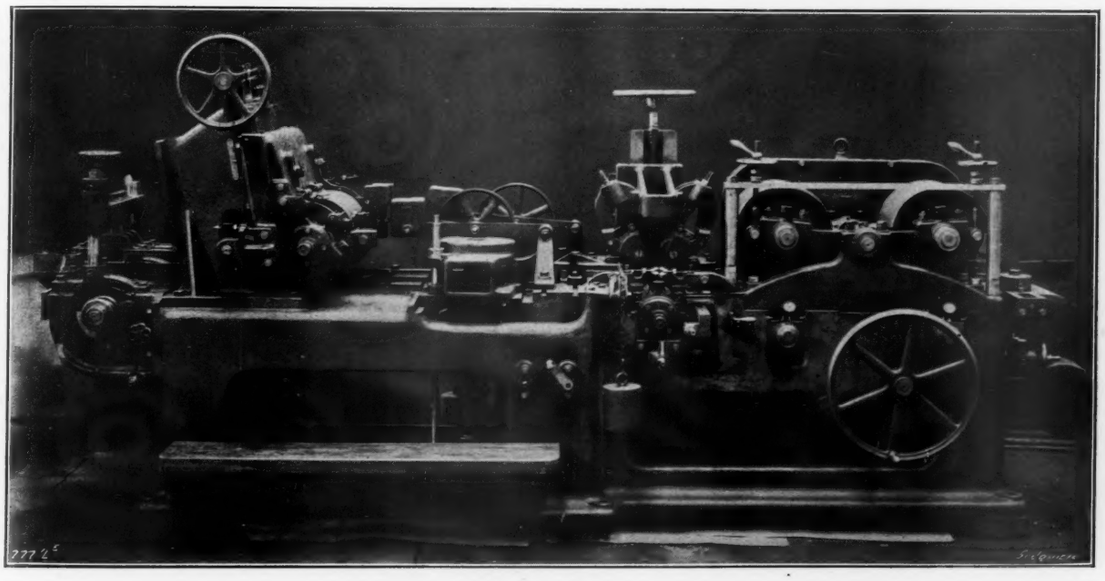


ND BOARDING PLANING MACHINE.

RANSOME LIMITED, ENGINEERS, NEWARK-ON-TRENT.

(For De[illegible]ge 365.)





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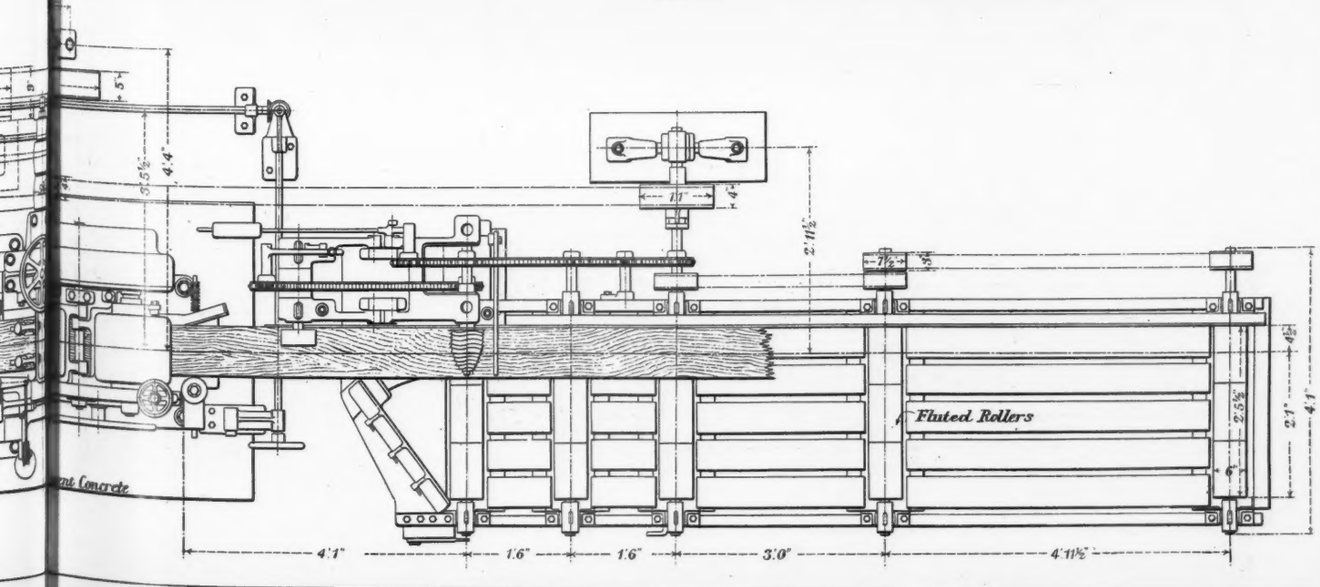
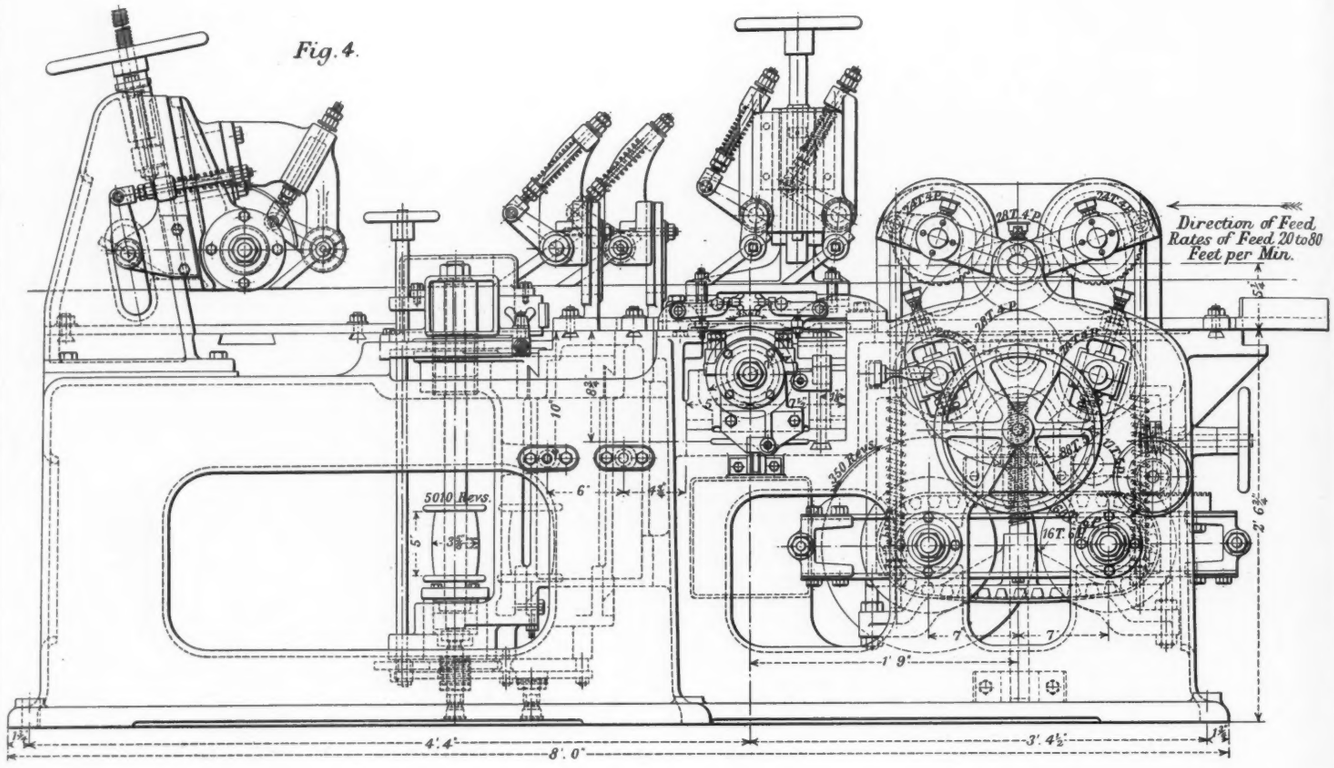


HIGH-SPEED WOOD PLANING AND MOULDING MACHINE.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LIMITED, ENGINEERS, NEWARK-ON-TRENT.

(*For Description, see Page* 365.)

Fig. 4.



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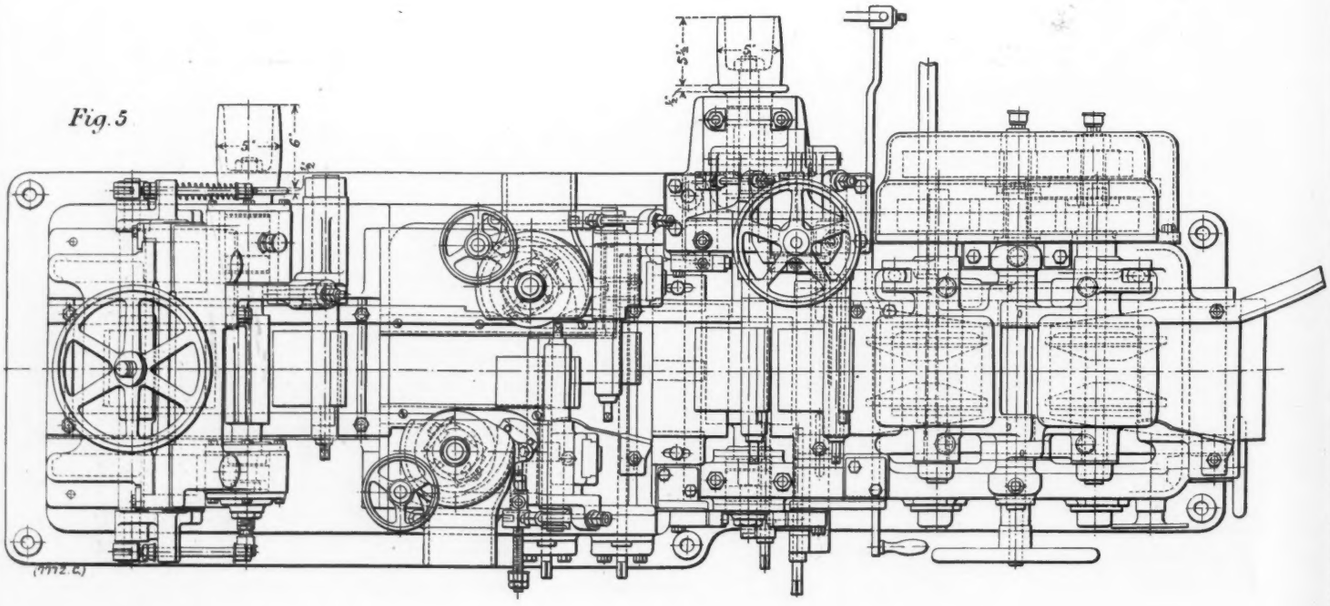

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ENGINEERING.

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ENGINEERING.

FRIDAY, MARCH 23, 1923.

THE MACHINE TOOL TRADE OUTLOOK.

THE machine tool industry is a sensitive barometer of trade generally, for its products are needed directly or indirectly in proportion to the demand for all those articles which go to make up our material civilisation. The connection between the output of machine tools and the production of mechanical articles is obvious, but the demand for textiles, food-stuffs and hundreds of other commodities equally stimulates the machine-tool trade by creating a demand for the machines by which those commodities are produced. It is in the nature of things, also, that the manufacturers of machine tools are among the first to feel the effects of a trade depression, and among the last to benefit by a revival. No one will order new machinery when he foresees that the sale of his products is likely to diminish, and even after the worst of the depression is past and consumption is again on the up-grade a natural caution prompts manufacturers to defer placing orders for more machines so long as they can manage to get along with what they have.

There is, we believe, a general confidence in industrial circles that the worst of the acute trade depression under which the country has been suffering for more than two years has definitely been passed, and that a slow but sure return to better conditions has set in. The cost of living, and therefore the cost of production has steadily fallen, our international credit and therefore our ability to purchase food-stuffs and raw materials from abroad has advanced to a point immeasurably superior to that of any of the European nations engaged in the late war, we are comparatively free from serious labour disputes and, taken all round, our industrial organisation, though certainly debilitated, is in a far healthier condition than it was in the feverish days following the armistice. For the re-establishment of our credit, upon which our whole existence as a trading nation depends, we have to thank the sound financial policy which the country has pursued, and although the deflation of currency and the balancing of income and expenditure have imposed a severe strain upon the population, the essential wisdom of our policy is not to be questioned. The medicine, however, has been drastic, and although it has protected us from the demoralization which has overtaken foreign credit and of which the end is not yet, it has left us with over a million unemployed. We believe, nevertheless, that the corner has been turned, and statistics of many kinds bear out this view. Trade is increasing and unemployment therefore is diminishing, while the soundness of the financial position relieves us from the threat of future industrial disaster which must be a nightmare to the statesmen of certain European nations.

The machine-tool trade, for the past few years, has found itself in a very unenviable position. During the war the demand for machine tools of all kinds was so great that every factory increased its facilities to the utmost, and the manufacture of tools was also taken up by scores of general engineering firms who had never built them before. In addition to this, machine tools were imported by shiploads from every country which could supply them. The consequence was that when the war was ended, machine-tool makers found themselves not only in possession of works equipped to supply an enormous demand, but also confronted with the existence of tens of thousands of machines which the Government and private owners wished to dispose of. Many of these, of course, were utterly worn out after their service, and others were special machines useful for nothing but shell-making, but of the remainder there were quite enough which could be reconditioned or which had seen little or no service, to prove a large factor in the machine-tool market. The disorganisation of the trade which would have been caused by ill-advised action in disposing of these machines was foreseen by the Machine Tool Trades Association, who made representations to the Government on the subject, and a gradual release was effected until a year ago it was stated by Sir Howard Frank, the chairman of the Disposals Board, that over 90 per cent. of the stocks declared surplus had been disposed of. The remainder of the stock was offered early this year at favourable prices and terms of payment to the makers and merchants who had supplied it, so that this disturbing factor may be regarded as no longer operative.

Although the unnatural stimulation of the machine-tool trade by the war and the consequent depression afterwards have done much harm by their unsettling effect on the industry, the war undoubtedly taught many useful lessons to those manufacturers who were wise enough to profit by their experience. The ordinary munition factory was engaged on testing machines to destruction on a colossal scale. Unskilled labour, working piecework, impelled by patriotism and exhorted by foremen to get the utmost possible output did wonders in the way of finding out the weak places of the machines and the various ways in which they could be spoilt by abuse or neglect. The value or otherwise of various features of design in regard to output was also made evident. Rows of imported machines working side by side with British machines on similar work and under similar conditions enabled valuable comparisons to be made as to their respective handiness and durability, and in general we believe our own makers gained credit by the comparison. The war-time experience should have benefited British manufacturers by dispelling for ever the idea that their products were not at least equal to those of foreign machine-tool makers, and it should have further aided them by indicating how they might make their machines better still. The advantage of quantity production of a limited number of models instead of dispersing energy over numerous different sizes and types of product was also brought home to machine tool factories, and efficient methods of manufacture became general.

In view of the circumstances we have mentioned there would appear every reason to look for a return to prosperity of the machine-tool trade in this country as soon as the revival of activity in other trades becomes a little more pronounced. It is at the same time highly important that efforts should be made to strengthen and consolidate our position in foreign and overseas markets, for the prestige of Great Britain as a maker of machine tools is not

only invaluable to that particular industry, but exercises a most beneficial effect upon our engineering reputation generally. Our machine-tool makers, as a whole, have made no concerted effort to cultivate overseas trade. The recent British Industries Fair, held at Birmingham, was organised under the auspices of the Department of Overseas Trade, specially to promote export trade, and thousands of invitations to be present were sent to buyers in all parts of the world. Yet British machine tools were almost entirely absent. The Machine Tool Trades Association, which comprises 135 firms in the industry, refused permission to its members to exhibit machine tools there. This, we think, was a most regrettable decision, and the more unaccountable as full permission was given to participate in seven other exhibitions during the year, most of which were of quite minor importance. A large group of stands at Birmingham devoted to the products of members of the association would have created at least as good an impression upon the foreign visitor, as the exhibit on similar lines which was staged by the firms comprised in the association of Drop-Forgers and Stampers.

That the Machine Tool Trades Association is not however, oblivious to the importance of overseas markets is shown by the support received at the annual general meeting on March 14, by a resolution that a machine-tool catalogue should be prepared in three languages for distribution abroad. The resolution, after a lengthy debate, was carried by a small majority, and although it will not become operative until it has been confirmed by a postal ballot of all the members, the debate showed that many of the latter were desirous that some effective action should be taken in the interests of export trade. Such a catalogue as proposed might be extremely valuable to the industry, but only if it were supplemented by an active trade policy. In the newer countries of the world the trade in machine tools is largely in the hands of merchants who carry enormous stocks at suitable centres of distribution. The existence of these stocks and their nature is constantly kept before the minds of the population by advertisements giving selections of the machine stocked, together with their prices. No ordinary purchaser is going to take the time and trouble to negotiate with a manufacturer in England about a machine, when he can obtain one which will suit his purpose delivered from stock in the country and invoiced to his nearest railway station in his own currency. It follows that in order to sell British machine tools on any large scale in such countries, either such terms must be made with existing merchant houses as will induce them to stock and advertise British goods, or our own manufacturers must combine and establish a stocking and selling organisation on a scale which no individual firm could afford to do. Then, and only then, we believe would the catalogue do really effective work.

THE AIR ESTIMATES.

THE most satisfactory feature of the Air Estimates, which were presented to the House on the 14th inst., is the indication they convey that the British Aircraft industry, which has experienced very lean times during the last two or three years, may expect a substantial increase in orders in the forthcoming year. The total net estimates for 1923-24 amount to 12,011,000*l.*, which exceeds the corresponding figure for the current year by 1,116,000*l.*, but the particular item which most affects the aircraft industry is the vote for technical and warlike stores. Under this heading, the estimated gross expenditure is 5,594,000*l.*, but 1,724,000*l.* of this is provided for by appropriations in aid, leaving the net estimate at 3,870,000*l.*, as compared with 1,295,000*l.* for the current year. The vote, however, now includes expenditure in connection with the experimental and research services which for the current year cost 1,177,000*l.*

The actual expenditure on machines, engines and spares for the ensuing year is estimated at 3,620,000*l.* gross, and presumably the aircraft industry will benefit to this extent, instead of by 1,524,640*l.*, which was the corresponding figure for the current year. The increased expenditure in the new estimates is due to the scheme of expansion of the air service for home defence, it having been decided to form 15 new squadrons for this purpose; about half the number will be completed in the forthcoming year and the remainder by April, 1925. Three additional squadrons for co-operation with the Navy are also to be formed during the year 1923–24.

This can hardly be said to be extravagant when it is remembered that France now possesses 1,260 service machines, of which the greater part are stationed in that country, while Great Britain has only 371 machines, two-thirds of which are employed overseas. Although the strength of the Royal Air Force has been increased from 31,176 to 33,000 in the present estimates, the net vote for pay has been reduced from 3,781,000*l.* for the current year to 3,508,000*l.* for next year, and the allowance for quartering, supplies, transport, &c., is also lower, being 1,351,000*l.* instead of 1,530,000*l.* Expenditure on works is estimated at 1,799,000*l.*, net and the cost of the Air Ministry is given as 648,000*l.* The meteorological and other miscellaneous effective services will cost 179,000*l.*, and the auxiliary and reserve forces 238,000*l.*, while 287,000*l.* is set aside as the probable cost of civil aviation. The latter item includes certain preliminary expenditure on the development of Croydon Aerodrome, and, in introducing the estimates, the Secretary of State for Air announced that in this direction it was proposed to proceed upon the general lines laid down by the Civil Aviation Advisory Board, which were explained in our issue of the 9th inst., on page 309. Subsidies to the aerial transport companies will be continued during the year on the present scale, but the Secretary stated that the Air Ministry was prepared to negotiate with any responsible person or persons to carry on the services on the basis of the subscription of 1,000,000*l.* of private capital with a State subsidy of an equal amount spread over a period of ten years; further particulars of this scheme will be found in our issue of the 2nd inst., on page 272.

The only other vote in the present estimates is one of 131,000*l.* for half-pay, pensions and non-effective services, but mention should be made of a statement by the Secretary of State for Air that it was proposed to offer prizes to the amount of 50,000*l.* in connection with competitive trials of helicopters. As far as we are aware, the conditions under which these prizes will be awarded have not been made public, but if they are such as to ensure the production of a reliable helicopter that would be really serviceable for military purposes the sum to be offered is by no means excessive. We, however, are not particularly optimistic as to the results.

NOTES.

CAST-IRON.

Researches in regard to steel and non-ferrous alloys are not engaging the attention of scientists to the exclusion of the more modest, if we may use the term, though equally important metal "cast-iron." One of the authorities in regard to the manufacture of this latter metal is Mr. E. Adamson, Sheffield, who in a paper on "Carbon in Cast-Iron" read on the 9th inst, before the Manchester Association of Engineers, stated that for nearly a quarter of a century he had systematically studied this subject. He confirmed a former statement of his to the effect that the real governing factor in pig-iron is carbon, which is controlled entirely outside of chemical analysis, by temperature, otherwise by physical treatment. His paper was an interesting review of the influence upon cast-iron of the carbon it contains in different forms. It gave particulars of a large series of tests in connection with some of which it stated that combined carbon could not be taken—as had usually been the case—as the most important factor. As an illustration, the paper added that square test bars, 1 in., $\frac{3}{4}$ in., $\frac{1}{2}$ in., and $\frac{1}{4}$ in. from the same ladle and of practically the same analysis, gave Brinell numbers of 175, 206, 216 and 301 respectively, the respective transverse tests, in hundredweights per square inch, being 24·07, 26·33, 28·97 and 34·12, the combined carbon being 0·40 per cent., 0·38 per cent., 0·34 per cent. and 0·37 per cent., respectively also. These results, the paper further stated, had been confirmed with test bars containing combined carbon 0·73 per cent., 0·69 per cent. and 0·32 per cent., very similar Brinell and Shore hardness figures having been obtained with each of these latter. Taking Mr. Adamson's paper together with one on "Cast-Iron as an Engineering Material," by Professor C. O. Bannister, read on the 7th inst. before the Liverpool Engineering Society, we find the two to agree in the matter of graphite and its degree of fineness as related to strength. The latter paper, however, added that "combined carbon increased the strength, but if in excessive amount caused great hardness and less resistance to shock"; this, among other points concerning cast-iron, might well be debated, we believe, at the forthcoming meeting of the Iron and Steel Institute.

THE MACHINE TOOL TRADES ASSOCIATION.

There was no note of depression with regard to the prospects of the machine-tool trade at the annual dinner of the association, at the Trocadero, on March 14. Sir Alfred Herbert, the president, stated his belief that the worst period had now passed, and that manufacturers had taken the opportunity afforded by slackness of trade to reorganise their methods with a view to greater efficiency. The President of the Board of Trade, Sir Philip Lloyd-Greame, confirmed the view that trade was improving and stated that real progress towards the recovery of our export trade was made last year. A deficit of 35 per cent. in exports during the previous year had been reduced to a deficit of 25 per cent., and the figures for last January showed still further improvement. The hope expressed by Lieutenant-Colonel J. A. Cole, president of the Society of Motor Manufacturers and Traders, that the other portions of the British Empire would assist us in peace as they had in war, drew from Sir Joseph Cook, the High Commissioner for Australia, a spirited defence of that country whose tariffs, he said, gave on the average a 15 per cent. preference to British goods. The imports of Australia from Great Britain had now surpassed the figures for 1913, so that Australia, at any rate, was doing what she could to foster Imperial trade. The burdens of taxation upon industry were touched upon by Sir Halford Mackinder, who reminded his audience that the payment of our foreign debt was inseparably connected with the lightening of taxation.

BRITISH CHEMICAL STANDARDS.

In a former issue (ENGINEERING, vol. cv, page 374), we gave particulars of a scheme promoted largely by Messrs. Ridsdale and Co., Laboratory and Technical Bureau, Middlesbrough, for rendering available chemical standards of iron and steel. Since the date of the article we refer to, April, 1918, the movement has progressed, and a general meeting of the co-operators was recently held at York, when a "Report on the Second Three Years' Working"—ending September 30, 1922—was read and details given of the work carried out during this period. As many as 53 analysts had taken part in the work of standardisation and 20 firms had provided material. Ten new samples comprising 46 actual standards were described. Particulars were also given as to the development of the movement in extent and in scope. At the present time, the standards were used not only by most of the large works' laboratories and many of the public ones in this country, but their use had so spread that sole agents had been appointed in Italy and in France. The 450 British and foreign users included 10 Government Departments, 30 Universities and technical schools and 5 railways. Moreover, the movement was gradually progressing further towards being self-supporting, without monetary aid from Government or other external sources. There was a world-wide choice of co-operators, and for each type of standard those recognised as specialists of large experience in the particular type and class of analysis were selected for the work. Among the resolutions passed at the meeting was one recommending that the fullest use be made of standard analysed samples of steel, iron and other substances: (*a*) By engineers in their specifications, referring regularly to some specific standard sample of similar type, and requiring that in cases of dispute a check analysis of it be made as a gauge of the values found; (*b*) by chemists, for periodically checking and co-ordinating their routine tests, and invariably as an aid to settling disputes, stating

in their reports that such standards had been used. A committee was appointed to consider the question of instituting on a financial basis a more formal organisation having separate official headquarters. Messrs. Ridsdale and their co-operators in this interesting scheme are to be congratulated for the progress it has made.

Electrical Development.

Although the application of electrical methods in factories and on railways is responsible for a large proportion of the current used and the appliances constructed, both the power station engineer and the manufacturer are none the less greatly interested in the smaller scale utilisation of electricity in the shop and home. Much has been done in these fields, but it is certain that enormous possibilities are yet latent, and that a proper cultivation of the domestic and shop loads would make a remarkable difference in the load factor of some of the power stations in our larger towns. The potential domestic user is little likely in most instances to investigate electrical possibilities for himself, and continual publicity and educational work is necessary if the consumption per head of electricity in this country is to be brought anywhere near to that of some others. Educational work of this kind might well be carried out to a greater extent than it now is, both on a national and local scale. The matter is naturally one of considerable expense, but the activities of the towns gas interests in the same direction suggest that it is remunerative. Works of this kind in the electrical field is the particular business of the British Electrical Development Association and more supply authorities might with profit enlist the aid of the Association in carrying out propaganda schemes in their own particular districts. The annual luncheon of the Association, forms an opportunity of bringing its activities to the notice of the Press and so to the public generally and the proceedings at the latest function of this kind, which was held at the Hotel Cecil on the 16th inst., suggested that the Association, which is still a young one, is making progress. All who are interested in the extension of the use of electricity in the domestic sphere in this country must realise the very important advantage which the gas companies possess in the fact that gas service connections are in existence for practically every house of any importance in our towns. The electricity supply people are far from holding a similar position, and it is part of the business of the Electrical Development Association to improve their relative position. Something may certainly be done by interesting the architect in this matter, and good should come from the discussion on "Co-operation between the Architect and the Electrical Engineer" which was held at the Institution of Electrical Engineers on the 15th and 22nd inst. The architects' side of the matter was dealt with by an introductory paper by Mr. F. Hooper, F.R.I.B.A., while the electrical side was represented by a corresponding paper contributed by Mr. J. W. Beauchamp, M.I.E.E.

Turbine Locomotive for Swedish State Railways.

An order has been placed with the firm of Nydqvist and Holm, of Trollhättan, Sweden, for the construction of a turbine-driven locomotive on the Ljungstr5m principle for the Swedish State Railways. We illustrated and described the Ljungström locomotive in great detail in our issues of July 21, August 4, 11 and 18 last year, so that we need only now remind our readers that power transmission from the turbine to the driving wheels is effected entirely by gearing and that a high vacuum is obtained by means of an air-cooled condenser. The locomotive, being equipped with air pre-heating apparatus, three-stage feed-water heaters and other features of the most modern power station practice did work on the road with only half the coal consumption of the best reciprocating locomotives on the Swedish Railways, while it also excelled the latter in rate of acceleration with a heavy train and in ease of manipulation. The new locomotive will follow generally the lines of its predecessor, although modifications of design are being made in connection with the arrangement of the air pre-heater, the gearing and the condenser elements. The boiler-car is to be carried on a four-wheeled bogie followed by three fixed axles, while the condenser car has three coupled driving axles followed by a four-wheeled bogie. The boiler car weighs 67·4 tons and the condenser car 76·5 tons. The total running weight of the machine is thus 143·9 tons, of which 54 tons are carried on the three driving axles. The total wheel base is 61 ft. 4 in., and the total length 73 ft. 2 in. over buffers. The boiler supplies highly superheated steam at 300 lb. per square inch gauge pressure, and a vacuum of 26 in. or 27 in. will normally be maintained in the condenser. The turbine will develop 2,000 effective horse-power at the rim of the driving wheels, and will give a maximum running speed of about 60 m.p.h., limitations in this respect being imposed by the Swedish State Railways. The locomotive is for mixed traffic service and is to haul passenger trains considerably exceeding in weight the 500 tons which represents existing practice in Sweden. The turbine, which is of the reaction type, has an unusually large number of rows of blades, which gives it almost constant efficiency over a large range of speed. This feature enables the engine to work economically under service conditions, whether hauling freight or passenger trains. Messrs. Nydqvist and Holm, who are well known Swedish locomotive builders, are constructing the present machine to the designs of the Aktiebolaget Ljungströms Angturbin of Stockholm, of whom they are licencees. It is interesting to note that the locomotive has been designed to conform to the British railway loading gauge requirements.

THE INSTITUTION OF NAVAL ARCHITECTS.

The annual meeting of the Institution of Naval Architects opened on Wednesday last, at the Royal United Service Institution, Whitehall, and was continued yesterday. Further sessions will also take place to-day. As usual in this issue, owing to the length of the discussions, we find it necessary to confine ourselves to the report of the proceedings of Wednesday, deferring the remainder for subsequent issues. At the Wednesday meeting, which commenced at 11 a.m., the president, His Grace the Duke of Northumberland, occupied the chair. The first item on the programme was the presentation by the Council of the annual report.

Report of the Council.

The report of the council recorded a further increase of names on the roll. The net increase for the twelve months was 148, compared with 143 in the previous year. The total number on the roll was now 2,888. The additions included an increase of members of 15; of associate members 60, associates 23, and students 50. The losses from death during the year included a number of members who had served on the Council, among whom were Mr. James Bain, Colonel Saxton White, Mr. A. Cleghorn, Sir James Marshall and Mr. H. R. Champness. Others included Admiral Sir A. de Horsey, Colonel J. M. Denny and Professor Terano.

The financial position was satisfactory. The amount collected for the work of the William Froude Tank had amounted to 1,220*l*. This was being transferred to the "Imperial Trust" for special expenses for research work. The Department of Scientific and Industrial Research contributed an amount equal to that raised for this purpose. The Benevolent Fund inaugurated last year amounted to 413*l*., having been subscribed to by 96 members. It was hoped that further support would be accorded this fund. A successful summer meeting had been held in Paris and Havre. (This was reported in these columns at the time and need not be further referred to). Honorary membership of the Institution had been conferred on M. Raiberti, French Minister of Marine, and gold medals to M. Bertin, M. Patry and M. Normand. Sir A. Denny had been elected hon. vice-president. The Institution was represented on the Joint Engineering Council by Sir J. Biles and Sir A. Denny. The Institution, as announced in the last report, was taking part in trials, to be conducted by a joint committee, on marine oil engines. A scholarship in marine engineering of 150*l*. per annum for three years had been offered by Messrs. Richardson, Westgarth and Co. The following awards had been made during 1922: Naval Architecture: Elgar scholarship to Mr. W. A. Sprague; Cammell Laird, to Mr. S. W. Bolwell; Armstrong, to Mr. R. L. Hughes. Marine Engineering.—Parsons, to Mr. C. E. Moffatt; John Brown, to Mr. D. Campbell. Post Graduate Research: Royal Commissioners, to Mr. W. G. A. Perring, R.N.C.; Sir William White, to Mr. H. J. R. Biles. The Earl of Durham prize was awarded to Mr. F. R. Crocombe. A gold medal had been awarded to Mr. E. L. Kent for his paper on "Experiments on Mercantile Ship Models in Waves," and premiums to Mr. R. L. Champness and Major L. Fea, respectively, for their papers on "Longitudinal Strength of Cargo Vessels" and "Some Consequences of the Washington Conference with Regard to Naval Construction." An education test had now been imposed upon candidates for admission as students.

Election of Officers.

The Secretary then announced the result of the ballot taken as usual prior to the meeting. The names of those elected were as follows: As vice-presidents: Sir Westcott S. Abel, Mr. W. J. Luke, The Right Hon. Lord Weir. As members of council: Mr. R. R. Bevis, Mr. James Brown, Mr. P. T. Caird, Engineer Vice-Admiral R. B. Dixon, Mr. A. E. Doxford, Mr. P. D. Ewing, Professor P. A. Hillhouse, Mr. L. Peskett, Sir Archibald Ross, Mr. F. J. Stephen, Sir G. Thurston, Engineer-Commander C. J. Hawkes. As associate members of council: Sir J. A. Ewing, Mr. W. L. Hichens and the Right Hon. Lord Invernairn.

The Presidential Address.

His Grace, the Duke of Northumberland, said that the situation of the Institution, as revealed in the report, continued to be of a most satisfactory nature; the increased membership and the financial position showed the element of soundness. While there was every reason for the Institution to congratulate itself on this result, it could not be said that the situation in the industry, whose interests the Institution served, showed any material improvement at present. He thought, however, that at least there were signs of resuscitation. Without being too optimistic, the industry might now look forward he considered to a gradual trade revival. Many factors were tending in that direction. Progress had been made in reducing national expenditure and in relieving taxation—by no means the least of those factors. Unemployment was gradually lessening, and it was a consolation to find an absence of those labour troubles which assumed such very serious proportions immediately after the war. It was to be hoped that the development of the principle of the Whitley Councils, and the system of insurance by industries, would be steadily pursued and would achieve success. The political conditions of the world, of Europe in particular, were, he feared, precarious. But even there, there was good ground for hope. The prosperity of Europe was dependent upon agreement between France, Great Britain and America, and it was to be hoped that the unanimity and co-operation which were in evidence last year at the Washington Conference might be extended to embrace the more difficult and more complicated affairs of the Western hemisphere.

He desired, in conclusion, to call attention to the remarks in the report regarding the research work being carried out at the Froude Experimental Tank. He hoped that further support might be forthcoming for this. He would like to suggest that those who owned ships derived benefit from the tank quite as much as those who built them, and the research was worthy of their support.

The Institution had received an invitation from the Royal Institution of Netherland Engineers at the Hague, and from the Nautical Technical Museum of Rotterdam, to hold their summer meeting in Holland, in September. This invitation had been cordially accepted by the Institution.

H.M.S. Victory.

The first item taken after the presidential address was a short paper by Sir Philip Watts detailing the condition of H.M.S. Victory and the work which would be necessary to ensure the preservation of this national relic. This communication is reprinted elsewhere in this issue. It was read by the secretary

and was followed by a few remarks by Admiral Sir Doveton Sturdee. Sir Doveton Sturdee stated that any information with regard to the appeal for contributions towards the preservation of the famous flagship could be obtained from his business address at 233, High Holborn. He drew attention to the fact that years ago Queen Elizabeth had given orders for the Golden Hind in which Drake sailed round the world, to be docked with a view to preservation at Deptford. Owing, however, to the neglect of precautions that vessel had subsequently gone to pieces. He hoped a similar experience would not be allowed in the present instance, and that the Victory would be preserved to the nation. He considered that this vessel, which had seen the development of our great Empire, was valuable from the point of view of teaching patriotism.

Co-operation of Aeroplanes with Steamships.

The President then called upon Sir Eustace d'Eyncourt, K.C.B., to read a paper on "A Proposed Aircraft-Carrying Mail Steamer," contributed by himself and Mr. John H. Narbeth, C.B. This paper which we reprint, with slight abridgment, on page 359, was presented in abstract form. The discussion was opened by Admiral Mark Kerr, who expressed his appreciation of the value of the idea presented in the paper. After referring to American experiments with strings and sandbags to effect landing on a deck, he spoke of the actual landing of an amphibian machine on a smooth deck as being much less hazardous than on the uneven ground at many aerodromes. In reference to the arrangements made for landing on a deck or leaving the ship the essential consideration is that of safety. Much must be sacrificed to ensure absolute freedom from accidents in the early stages of operation of such a scheme, for an early mishap may set back the development of the proposed scheme for many years. A field of service not referred to by the authors, but one of gigantic importance, is the carrying of money and light, but valuable, freights. In this activity any saving of time may be the means of saving enormous sums in interest due to the lengthy time of present modes of transport. The air routes of the future will be served by fast machines of large size and linked up with points to each side of the main route by the use of small but fast planes. For the sake of safety all machines on the suggested service in association with steamships should be equipped with twin engines.

Engineer-Commander Robinson followed, and referred to the value of the impression created by the authors of the paper on the necessity for mutual co-operation between the naval architects and the aeronautical engineers in dealing with the development of the association of aeroplanes with steamships. Such a far-seeing inspiration, as that presented, deserved all the backing they could give it, that it may be carried to a complete and full success. Flying men must all be impressed with the value of the services which could be rendered by the naval architects of the country in extending the commercial use of aeroplanes.

Engineer-Captain Onyon continued the discussion by referring to the early proposals made by his firm, Messrs. Beardmore, regarding carrying the funnels of the Argus horizontally to the stern of the vessel.* This suggestion was mooted as a means of obtaining a perfectly clear deck for an aeroplane carrier. The Admiralty were at first very doubtful about the feasibility of the scheme, but were later convinced, and after the refitting of the vessel the suggestion was found to prove a very successful solution of the problem. With the Argus it had been demonstrated beyond all question that landing upon the deck of a vessel at sea was in every way a practical proposition for an aeroplane. The induced draught fans to get rid of the smoke for a large vessel of this type present some difficulties. With any increase in the power of a vessel the dimensions and power of the fans must be increased at a greater rate than the mere proportionality to the engine power. With very high-powered steamships the fans may need to be of very large size.

Wing-Commander Cave Brown Cave supported the proposed co-operation scheme between ships and aeroplanes most strongly. One difficulty he anticipated, however, is the disadvantage of having to head the boat to the wind at the time of landing. This seems a disadvantage, but it was anticipated that the difficulty would not prove unsurmountable. The claims made for the proposals seemed to be quite reasonable. Our equipment of about 20 aeroplanes, such as was proposed might be housed in the hangar accommodation, required more aviators, mechanics and other workmen than the 20 suggested. For so many machines about five times the number of men suggested would be necessary. The sizes of the lifts limited considerably the size of the planes which could be used in the proposed service. That limitation could be greatly reduced by the general co-operation of different ships in the scheme. The man who desired to save time by flying on to a liner may, after a time at sea, feel disposed to push ahead at a faster rate than the ship, and desire to leave the boat he originally joined to fly to another some distance ahead. By the general co-operation of ship owners, great savings in time could be ensured in that way. A general scheme of that sort would save enormously the time of transport for those passengers and also for certain types of goods, when savings in time are imperative. By the use of a general scheme such as he suggested the aeroplane would be put to more efficient service, as otherwise the long periods of their inactivity on a boat would mean enormous loss.

Engineer-Commander Bird who followed referred to the formation of the Joint Engineering Council, mentioned in the Annual Report, and suggested the necessity for the Association of the Royal Aeronautical Society with the engineering institutions as a means towards the development of aeroplane service. The machines suggested for use in the proposed schemes are all of the land type—and not so suitable for the service intended as amphibian machines. There is an essential difference between the conditions for flying on to and flying off a ship. The effects of weather must be considered. In a dead calm flying on to the vessel is much more difficult than flying off because for the latter a catapult device may be used to facilitate the action. One thing is certain, and that is that safety must be the primary consideration. In the suggested vessel the mast should be removed because of the possibility of its presence proving terrifying to the passengers.

Captain D. Nicholson was the next speaker, and spoke very critically about the construction of flying boats which he considered were exceptionally weak before they were redesigned by naval architects. Before long the whole of the postal service across the North Sea would be carried on with amphibian aeroplanes. The possibilities have been amply demonstrated by the flight of a flying boat round Scandinavia, with 44 flying hours to its credit, and 27 days away from its home station, and without experiencing any damage or trouble. The use of such machines on postal work is thus shown to have been raised from the level of a mere possibility to a certain success. The figures of costs given in the paper must be viewed, he thought, with suspicion. The total life of an airship and the number of days it can fly must be considered in determining the cost per ton mile of service and the figure given for airships would need to be about 4*l.* rather than the 4*d.* mentioned. Total cost figures, accounting for all the factors are the only ones of use, and others may create erroneous impressions in the minds of the general public. The types of machines suggested by the authors are not suitable for the service intended, amphibian machines are the only ones which would be found useful in such work.

Sir Henry White-Smith expressed his appreciation of the spirit of co-operation shown by the naval architects and the aeronautical engineers, and looked for progress from their association. He thought the last speaker unduly severe in his condemnation of the early flying boats. Naval architecture is a subject with a history and with an accumulated experience to work on, but the aeronautical people had many problems for the solutions of which they had to grope in the dark. The necessity for large stowage accommodation on steamships seems to be a myth. With well-equipped shore stations with wireless installations, the aeroplanes could be kept on shore and sent out to the boats at both the beginning and the end of the journey. With such a scheme in operation the planes could be kept in first-class order and the stowage space on the ship saved for other and more profitable use.

Mr. P. R. Jackson referred to the necessity for stabilising vessels of the type suggested to facilitate the landing on the deck of the aeroplanes, and was followed by Mr. Bryant, of the National Physical Laboratory, who desired to emphasise the necessity for close attention to the results of aeronautical research in dealing with such proposals as those suggested by the authors.

Mr. John H. Narbeth, in replying, thanked the members for their appreciative comments on the suggested scheme put forward by Sir Eustace d'Eyncourt and himself. The idea of the horizontal funnels arrangement to make possible the obtainance of a clear deck for an aeroplane carrier was undoubtedly due to Messrs. Beardmore. The table of machines used in estimating the stowage possibilities were not suitable for the work intended, but in the absence of particulars relating to the machines which would be developed for the purpose the authors made use of the particulars which were available but recognised, with many who took part in the discussion, that machines of the amphibian type were necessary. The machines carried on the ship are out of proportion to the personnel thought necessary for their maintenance and flight, but it was not proposed that all the machines carried should be on service at the same time. Shore stations had been thought of in connection with the proposed service, and their use was contemplated, as possessing many advantages.

Coastal Motor Boats.

The first paper to be taken after the lunch interval was a joint contribution by Sir John E. Thornycroft, K.B.E., and Lieutenant Bremner, R.N., D.S.O., entitled "Coastal Motor Boats ('C.M.B.'), Their Design and Service During the War." This paper, which was read by Sir John Thornycroft, will be reprinted in an early issue, so that we need now only give a brief summary of its contents.

In the early summer of 1915, the authors remarked, the possibility of utilising quite small motor boats to go over the minefields and attack the German bases was suggested by Lieutenants Hampden, Bremner and Anson. It was finally decided that to give any chance of success, such boats must complete with an 18-in. torpedo, should not weigh more than 4¼ tons and have a speed of at least 30 knots when fully loaded. The experience gained by Messrs. Thornycroft with fast racing boats and particularly with the skimming boats having hulls designed with a series of inclined planes on the bottom as proposed by the late C. M. Ramus, rendered them confident that the required conditions could be met. No ordinary form of torpedo discharge gear could be brought within the necessary limitations of weight, and it was decided to incorporate the arrangements for carrying the torpedo in the structural design of the hull itself. The boat, moreover, had to be able to discharge its torpedo at full speed, and ultimately, taking account of all considerations, the torpedo was carried in a trough in the after part of the boat and discharged over the stern. The design was approved by the Director of Naval Construction and 12 boats of the type, 40 ft. in length, were ordered. The exact form of the hull was decided on after careful model experiments, and the average speed of the first boats was 33·5 knots with 250 h.p., the screws having a pitch of 35 in. and a diameter of 22·5 in., and the total displacement with fuel, crew, torpedo and seagoing gear on board being 4·25 tons.

After the success of the 40-ft. boats had been proved, a large number of 55-ft. boats of about double displacement, fitted with twin engines and carrying either two torpedoes or a torpedo and depth charges were built. The first few of these had two engines of 250 h.p. each, but afterwards the engine power was increased and, with two engines of 375 h.p. each, a speed of 40 knots when fully loaded over a 2 hours' trial was obtained. The construction of these boats is described and illustrated in the paper. The torpedoes were discharged by long stroke rams operated by the pressure of burning

* We fully described and illustrated the Argus in vol. cvii of ENGINEERING, pages 401, 430.

cordite, the gas pressure of about 4 tons per square inch in the explosion vessel being throttled down to 1,000 lb. per square inch by passing through a small orifice. A comparison between the old second-class torpedo-boats and the 55 ft. C.M.B.'s shows that though the latter were 8 ft. shorter they had a speed of 38 knots on a 2 hours' run as compared with 15 knots, they carried 18-in. torpedoes instead of 14-in., a crew of five men instead of eight, and displaced 12·20 tons instead of 12·89 tons.

War experience showed that the C.M.B.'s, small and light as they were, could stand quite bad weather and attack successfully after making runs of 50 miles to 100 miles. They were, of course, uncomfortable boats which could only be manned by hardy young men. The earlier 40-ft. boats were intended to be carried to the scene of action in the davits of light cruisers, and though the larger ones were not intended to be used with a parent ship, it was nevertheless inadvisable that they should be in the water except when in use, and they were adapted structurally for being taken out of the water by cranes or slipways at naval bases. The authors consider that despite the special advantages of the amphibian, or flying boat, there will always be scope for fast vessels of the pure surface type, and they conclude their paper with some interesting accounts of the exploits of some of these vessels during the war. An excellent model of one of the 55-ft. C.M.B.'s constructed by Messrs. Thornycroft was brought to the meeting for the inspection of the members, and another exhibit of great interest was the first model of a hydroplane hull, made by the Rev. C. M. Ramus about forty-five years ago, and lent by his son for the occasion. This was perfectly rectangular in plan, with vertical sides and stern. The front was curved up like the front of a sleigh, and the bottom consisted of three inclined planes of approximately equal length, disposed like the teeth of a ratchet, and leaving two transverse edges at their junctions.

The discussion was opened by Captain De Villarey, who had lectured on the work of the Italian torpedo boats in the Adriatic during the war at the Royal United Service Institution in 1919. He considered that the success of such boats as the C.M.B.'s was made possible by the development of the high-power light petrol engine but the work of the men who ran them and of the firms who built them must also be recognised. He recounted incidents of the war which demonstrated the value of the boats, referring to the torpedoing of the Austrian battleship Budapest in broad daylight while she was engaged in bombarding the Italian Coast. The motor boat, although under heavy fire and riddled with bullets, kept afloat until she had returned to her base. For tactical purposes a ship specially designed as a motor-boat carrier would be just as useful as one for carrying aeroplanes. As regards the future of the motor-torpedo boat some improvement in speed might even yet be possible, but boats of this class should not much exceed 50 ft. in length, as to do so would be to sacrifice somewhat the protection from gunfire which their small size now afforded them. Captain De Villarey hoped that sportsmen would continue to take a keen interest in motor-boat racing, as this afforded valuable instruction to the naval designer.

Mr. Syndey Barnaby said that those who could remember the old second-class torpedo boats would best realise the tremendous advance which was marked by the C.M.B.'s. There were three points in which the latter showed marked superiority. In the first case the newer boats were more seaworthy as they had a much greater ratio of beam to freeboard. Secondly, their reliability was much greater. The locomotive type boilers used in the second-class torpedo boats were anything but reliable on account of their disposition to priming. The speaker would not like to have to guarantee a 2-hours' trial at full speed with a locomotive boiler, because of this defect. The third advantage was in the method of discharging torpedoes which had been adopted. He had known torpedoes discharged over the bows of torpedo boats to go down and bury their noses in the mud, and the improvement which was brought about by discharging them over the stern was enormous. The spiral type of propeller was suggested by Sir John Thornycroft, and it had proved remarkably efficient, giving a speed of 37·2 knots as against 38·4 knots for the best propellers of standard design.

Mr. John Smith remarked that early in the war the Admiralty had issued invitations to shipbuilders to put forward designs for boats of the C.M.B. type. The invitations were quite general and a great deal was left to the initiative of the firms concerned. The Admiralty had suggested that such boats should carry a downward projecting horn or ram which should deal with submarines after the manner of a can opener. Until Sir John Thornycroft's paper the characteristics of C.M.B.'s had never been authoritatively put forward, and the paper was therefore very valuable. It was very undesirable to construct a rigid hull either for seaplanes or for boats of the C.M.B. type, and in both cases a somewhat similar type of construction had been found necessary. The incorporation of the torpedo launching arrangements in the hull was one of the features which made the boats possible and the combination of speed, armament, size, &c., which had been obtained was a remarkable feat.

Sir John E. Thornycroft in reply expressed his regret that the requirements of the Service had prevented Lieut. Bremner from being present as he had had about the earliest practical experience of the behaviour of a C.M.B. It was not only the firms who built these vessels who deserved credit for their construction, credit was also due to the Director of Naval Construction and to his staff. The problems to be solved were both difficult and interesting, and there was no doubt further progress to be made.

A cordial vote of thanks was accorded to the authors, on the motion of the President.

PRESENT DAY SHIPBUILDING PROBLEMS.

The President then called on Mr. A. C. F. Henderson to read his paper entitled "Remarks on some of the Present-day Problems in the Design of Ships." We publish this paper on page 383 of this issue.

The discussion was opened by Sir Westcott Abell who said that he believed that it was the first time that a shipowner had contributed to their proceedings, and he congratulated the author on breaking fresh ground. He thoroughly agreed that there was a need for closer co-operation between owner and designer. The latter needed greater opportunity for studying the behaviour of ships at sea, and the economics of the subject whilst the shipowner should on his part study the limitations imposed by technical considerations. He thought this course should be followed even where ordinary cargo steamers were concerned. In general he thought that it was the space required for imports which fixed the economic value of a ship. Lloyd's register were accordingly attempting to frame new rules which would give designers greater freedom with respect to deadweights and capacities. He asked that ship owners should give facilities to post-graduate students to get sea experience. At Liverpool steps in this direction had been taken by the Holt Line and the Booth Line. He gathered that the author assumed the early appearance of the 1,000 ft. steamer. This would be a purely passenger proposition. With regard to the matter of stability it might be said that at present it was judged on static conditions, but for the past 10 or 12 years the speaker had been emphasising the importance of dynamic factors. Here again, he thought, there was an opportunity for research at sea by naval architects provided with proper apparatus for recording the rolling and pitching of different vessels. An analysis of data thus obtained would help to safeguard stability. In this connection he might add that steps had been taken to compare the results obtained with models by Mr. Baker at the N.P.L. with the actual behaviour of the full-sized vessels at sea. One point on which the author had hardly touched was the stability of a vessel when damaged. To some extent this had been legislated for, and one or two private firms did require that their ships should remain upright if a compartment were flooded in the worst conditions. Shipowners were now in considerable difficulties in the matter of propelling machinery of large power, and he would suggest greater co-operation in this matter between the shipowner and the marine engineering firms. The amount spent by the latter in research must have exceeded £500,000, and to this the shipowner had contributed nothing.

Sir Kenneth Anderson spoke next, and said that he agreed with the author in believing that ships tended to increase in size. In this matter they were governed by two conditions, viz., economic and commercial considerations, and secondly by physical limitations. The North Atlantic trade was more favourable to ships of large dimensions than the Eastern or Australasian trades, in which the rate of growth was slower. This was due in part to a less rapidly developing traffic, and in part to the restrictions imposed by the Suez canal. Nevertheless there was a tendency to growth in these trades since given the proper facilities for handling such ships and the traffic to fill them, large ships were safer, more comfortable and more profitable than smaller ones. As the author had pointed out, increases in ship dimensions had generally anticipated the previsions of the dock authorities, but he hoped that this tradition might be reversed for the future. With regard to machinery, he might say that the Diesel engine was handicapped by existing rules for tonnage measurement. In order to get the benefit of the 32 per cent. allowance for machinery space it was necessary that the machinery should occupy at least 13 per cent. of the gross tonnage. Actually Diesel engines could be obtained which occupied 38 per cent less space than corresponding steam engines, and hence if the 32 per cent. allowance was to be claimed, some of this gain would have to be surrendered. He thought, therefore, that the minimum of 13 per cent. might well be reduced to 8 per cent. Another question arose here, however. Under the convention cargo space was credited with a permeability of 60 per cent., whilst the permeability of passenger space was fixed at 95 per cent. For steam machinery space the permeability was taken as 80 per cent., the corresponding figure with internal-combustion engines being 80 per cent. Hence the change from steam to oil raised the permeability figure from 80 per cent. to 85 per cent., but since the space saved with the internal-combustion engine was used as 'tween deck passenger space, it had to be debited with a permeability of 95 per cent. He was surprised that practically nothing was said in the paper on the question of subdivision, as it was very important that we should have as soon as possible regulations on this head at once, definite, simple, of direct applicability and of international scope; which whilst securing safety of life and freight should be compatible with practical and economic conditions. We must provide adequately for normal dangers, but it was unwise to attempt to provide for the abnormal, and the regulations imposed by the existing convention had a most crippling effect on the design of passenger ships. The present position was intolerable, and the question of reforming the rules regarding subdivision was most urgent.

The President said that as originally submitted Mr. Henderson's paper had comprised a long section dealing with this question of subdivision, but the discussion of the problem was considered unwise at the present time, and the author had accordingly been asked to omit this section from his paper.

Mr. W. J. Luke said that the naval architect would require to study Mr. Henderson's paper for a good many months before he could adequately discuss it. He never remembered a paper submitted to the Institution which so well merited the attention of all its technical members. In the case of the first two vessels referred to in the appendix, the metacentric heights in the first instance range from 0·46 ft. with ship light, to 4 ft. 6 in. in the fully loaded condition. The corresponding figures for the second vessel being $\frac{1}{2}$ ft. and $3\frac{1}{2}$ ft. He thought that naval architects must study the designing of ships so as to avoid such an enormous variation on the metacentric height. The problem was not made easier by the rise in the height of the centre of gravity of the propelling machinery. He could not say whether much improvement was possible, but it was eminently desirable.

Mr. A. T. Wall spoke next. He said that speaking

as a naval architect he considered the paper of very great value. He was glad that the author put the principal blame for lack of co-operation between shipowner and ship designer on the shoulders of the former. Many of the problems raised by the author led to complicated calculations, which were often avoided, but difficulties did arise after a ship was launched. They had to be made, as the faults could not otherwise be remedied. Unfortunately such calculations were commonly classed as theoretical and the term often implied an aspersion. No doubt the exclusively theoretical men did make mistakes but so did the mere practician. The adequate discussion of the problem raised by the author took time and technical assistance, which was not always forthcoming. Design was often not gone into until the decision to build, and there was then an impulse to get the keel laid as soon as possible, and once this was done little modification was possible. He would point out that a small metacentric height was not essential for comfort. This view was not, however, generally accepted, and the adoption of a low metacentric height for ease in a seaway might involve a dangerous reduction in the margin of safety. Consideration showed that the metacentric height might be increased with the size of the ship nearly as in the square of the beam, and were this done they need not be afraid of having an uncomfortable ship, and the speaker believed that such ships would be safer and more economical. They could then dispense with water ballast in the loaded condition and would gain additional top cargo space.

Mr. Perring, who followed, said that he thought the 32 ft. depth of the Suez Canal and the 40 ft. depth of the Panama Canal would largely influence future design. He added that on the Pacific side of the Panama Canal only 35 ft. was available at low tide in the approach. Since it was known that for every ship there was an economic speed dependent upon displacement, freight rates and distance, he thought that ships should be designed for particular trades. With two similar ships, one N times the size of the other, the longer ship would have N times the metacentric height, but its period of roll would be increased in the ratio $\sqrt{N}$. Hence, the greater metacentric height gave the easier ship. In practice large and small ships were not similar since the draught did not increase so fast as the length and beam; yet, nevertheless, we could have a large ship with a greater metacentric height rolling at the same speed as a smaller vessel. With respect to increased beam it should be borne in mind that in cases of damage there was a larger loss of area than with a smaller beam.

Mr. John Anderson spoke next, and welcomed a paper from an owner on the principles of design, the more so in that principles only had been dealt with and not details. He did not suggest that owners should confine themselves to laying down merely speeds and overall dimensions, but many specifications went into minute detail and were evidently copied from past and often obsolete practice.

He could hardly express the bitterness he felt when handling such specifications, and shaping them into form. The work thus imposed was so engrossing that one was apt to lose sight of broad principles, which if attended to, would produce a better ship. In one case a specification called for a metacentric height of 3 in. light and not more than 9 in. loaded, whilst the deadweight asked for would require a metacentric height of 2 ft. 6 in. at least. Captains were very well in their own place, but abstruse problems should be confided to the naval architect. The author had predicted vessels of 1,000 ft. length and this would interest civil engineers as well as naval architects. He gathered that such vessels were held to be profitable in spite of the losses inherent in laying them up for the slack season. He would like to have a comparison as to the relative financial efficiency of a 600 ft. 16-knot vessel reasonably filled all the year round and a 1,000 ft. 21-knot vessel which could be run full for four months in the year. If it could be shown that the large ship was the more profitable, he thought that dock authorities might be influenced. He regretted that the author's tables did not include particulars of the intermediate type of vessel carrying cargo in one direction only. Such vessels must have adequate stiffness in ballast trim and should, he thought, be high sided. As for the 4 ft. 6 in. metacentric height of the Aquitania, he asked if full allowances had been made for conditions of the tanks. It was difficult to compare the Aquitania with other ships as she was fitted with an anti-rolling tank. His own experience was that an easy rolling ship was much preferred by passengers. He was glad to have the data as to the water ballast added to get adequate metacentric height on unloaded conditions. The figures agreed with his own opinion as to the minimum practicable.

In reply, Mr. Henderson said he could not give offhand the figures as to the relative financial efficiency of the two types of vessel referred to by the last speaker. As a matter of fact, the smaller vessel could not be run full all the year round.

THE ANNUAL DINNER.

The annual dinner which was held at the Connaught Rooms on the evening of Wednesday, was as usual a very successful function, and some 600 members and guests assembled. The speeches which form an item at gatherings of this kind were, we thought, distinctly above the average. After the loyal toasts had been given by the President, the Duke of Northumberland, His Grace proposed the "Royal Navy" in a happy speech, and the Right Hon. L. S. Amery, the First Lord of the Admiralty, who replied, gave some interesting but, to a gathering of naval architects, rather distressing figures of the naval material which had been scrapped by this country since the armistice. The total figure amounted to about 2,000,000 tons. The toast of "The Mercantile Marine" was given by Earl Beatty, the First Sea Lord, who expressed the mutual esteem which existed between the Navy and the Merchant Marine and which had been so strengthened by the common service they had seen during the war. He pointed out, in reference to the loss of material by the Navy dealt with by Mr. Amery, that the Merchant Marine had suffered similar and equal loss. This toast was replied to by Sir Ernest Glover, President of the Chamber of Shipping of the United Kingdom, who as a shipowner, apparently did not yet feel that all was well with our shipping trade in spite of all that has been said about recovery. The toast of "The Guests" was proposed by Sir Archibald Denny and replied to by His Excellency the French Ambassador.

(To be continued.)

INDUSTRIAL NOTES.

SOME remarks by Sir Philip Lloyd-Greame on the advisability of encouraging emigration to other parts of the Empire as a means of alleviating the unemployment now so prevalent in Great Britain, brought forth a vigorous denunciation of emigration as a policy from Mr. J. T. Brownlie, the president of the Amalgamated Engineering Union, at the annual dinner of the Machine Tool Trades Association last Wednesday week. The true wealth of a country, said Mr. Brownlie, lay in the numbers of its healthy and intelligent citizens. There was no question of over-population, though a serious social danger lay in the inadequate proportion which the best elements of the community contributed to the population. An American gentleman had recently told the speaker that he estimated that every young skilled mechanic who emigrated to the States represented an addition to the wealth of that country which might be capitalised at 10,000*l.*; Great Britain could not afford to train up such men for export. Overproduction, in Mr. Brownlie's opinion, was another myth. So long as people were in want of anything there was no such thing as over-production. The present depression of trade was due to under-consumption, not over-production, and under-consumption was intensified by wage reductions. The American employer paid far higher wages than the British employer and yet he could enter into effective competition with him. The workmen for whom Mr. Brownlie spoke had no objection of any kind to the introduction either of labour-saving machinery or of efficient methods, and they would welcome any improvement in machinery if they could be assured that it would not result in them or their fellows losing their employment or having their standard of living reduced.

The Ministry of Labour report that employment showed a further improvement during February. It was good at coal mines, in steel sheet manufacture, and in the worsted trade; fairly good in the tin-plate trade, and fair in the iron and steel, woollen, and paper trades. In most of the other large industries employment continued slack, but some improvement was reported in the iron mining, pig-iron, engineering, shipbuilding, building, furniture and pottery industries. The percentage unemployed among members of trade unions from which returns are received was 13·1 at the end of February, as compared with 13·7 at the end of January, and 16·3 at the end of February, 1922. The total number of workpeople registered at the Employment Exchanges as unemployed on February 26 in Great Britain and Northern Ireland was approximately 1,376,000, of whom 1,073,000 were men and 218,000 were women, the remainder being boys and girls. On January 29 the corresponding total was 1,460,000, of whom 1,138,000 were men and 226,000 were women.

In the industries for which statistics are compiled by the Labour Department the changes in rates of wages reported as having taken effect in February resulted in an aggregate reduction of 64,000*l.* in the weekly full-time wages of nearly 480,000 workpeople, and in an increase of 400*l.* in the wages of nearly 8,000 workpeople. The principal groups of workpeople affected by reductions included iron puddlers and iron and steel millmen in the Midlands, and steel smelters in most districts, who sustained a decrease of 2½ per cent. on standard rates in each case, equivalent to from 1¾ per cent. to 2 per cent. on current rates. Among other large bodies of workpeople whose wages were reduced in February were men employed in non-federated shipyards at Belfast and in ship-repairing yards on the Mersey; gold, silver and jewellery workers at Sheffield; coopers; flour millers; and workpeople in the electricity supply industry in various districts. The principal group of workpeople whose wages were increased in February were iron ore miners in Cumberland, who received an increase of 3*d.* per shift. During the first two months of 1923 the changes in the rates of wages reported to the Labour Department have resulted in a net reduction of over 120,000*l.* in the weekly full-time wages of about 950,000 workpeople and in a net increase of 43,000*l.* in the weekly wages of 670,000 workpeople.

On March 1, the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was approximately 76 per cent. above that of July, 1914. The corresponding figure for February 1 was 77 per cent., and that for March 1, 1922, was 86 per cent. The highest point reached was 176 per cent. above the pre-war level, in November, 1920, and the present figure is the lowest recorded since May, 1917. For food alone the increase on March 1, as compared with July, 1914, was 71 per cent.

The number of trade disputes, involving stoppages of work, reported to the Department as beginning in February, was 41. In addition, 36 disputes which began before February were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in February (including those workpeople thrown out of work at the establishments where the disputes occurred, though not themselves parties to the disputes) was approximately 40,000, as compared with 19,000 in the previous month and 30,000 in February, 1922. The estimated aggregate duration of all disputes during February was 337,000 working days, as compared with 117,000 days in January, 1923, and 269,000 days in February, 1922. The principal disputes in progress during the month involved about 9,000 coal miners near South Shields and about 4,000 workpeople in the bookbinding trade in London.

With further reference to our reports in former issues concerning the situation in the building trades, it is now possible to give the result of the ballot taken by the men with regard to the employers' terms. The figures are as follow:—

For acceptance	42,606
Against	104,952
Majority against	98,346

From these figures it will be seen that a larger number of votes than the 20 per cent. majority required for strike action to be taken have been obtained. There is, therefore, the possibility of a national stoppage of 500,000 men on April 1. The employers are holding meetings to consider what action they will take in view of the above results of the ballot. This ballot, like all others taken in recent times and bearing upon vital questions which affect the whole of the community, is remarkable for the limited number of voters compared with the union membership. In this

particular case, the figures are 183,558 and 500,000, giving a proportion voting of barely 40 per cent.

Coal-mining in South Wales is again going through a period of difficulty. Twenty thousand miners have ceased work, and more than double that number have given notice to cease work in a fortnight. The trouble is due to the fact that many miners are either non-union men or members, we are told, of the Mechanical Workers' Union. The Miners' Federation are making every effort to get all the miners to join the Federation.

THE INVESTIGATION OF MACHINERY NOISES.

As most engineers are familiar with the use of some simple form of stethoscope for the detection and location of noises produced by machinery, it may be of interest to refer briefly to improvements recently made in these instruments in order to extend their range of usefulness. The development of the apparatus has been largely due to the work of Mr. C. E. Noël-Storr, the managing director of the Capac Company, Limited, 18, Bruton-place, New Bond-street, W. 1, who dealt with the different types of instruments available, and described some of their applications, in a paper read before the Coventry Branch of the Institution of Production Engineers, in November last. Since that time, however, an interesting and important improvement in the apparatus, which we propose to describe later, has been made.

As applied in its simplest form for the location or investigation of internal noises such, for example, as that produced by the slap of a slack piston on the cylinder walls of an internal-combustion engine, the instrument comprises a reproducer somewhat resembling a telephone receiver and connected by thick walled rubber tubing to a pair of ear tubes. The reproducer, which is constructed entirely of metal, contains a stout metal diaphragm to one side of which the end of a thin steel rod is connected. The free end of the rod is placed on the part of the machine it is desired to investigate, and the sounds are transmitted through the rod to the diaphragm and thence through the air in the rubber tubes to both the user's ears. By applying the end of the rod to different parts of a machine, such, for instance, as a motor-car engine, it is possible to locate and listen to any particular internal noise with little or no disturbance from the various extraneous noises. If the user has sufficient experience in the working of the machinery under investigation it is not difficult to diagnose the cause of the noise and to prescribe the remedy.

A fairly obvious development of the apparatus above described is the use of two reproducers, the rods from which can be applied alternately or simultaneously to two similar parts of one machine or to two different machines for the purpose of obtaining a rough comparison between the noise produced by each. It should be noted, however, that connections from both reproducers are brought to both the user's ears, and not one to each ear, the former arrangement eliminating any discrepancies that might otherwise arise from acuity differences between the two ears; the results would, in fact, be quite unaffected if the user were completely deaf in one ear. Apparatus of the type just described might be used for comparing new units, such as gear-boxes, with a checked and corrected standard part running under ideal conditions, though, as so far explained, the comparison would depend largely upon the user's judgment. To eliminate this factor as far as possible, a sector valve is fitted in the tube leading from each reproducer and by partially closing one of the valves the louder noise can be reduced to bring both the sounds heard to the same intensity. This adjustment is not difficult to effect, and when it has been made the difference in the valve openings, as indicated on the sector scales, is a measure of the extent by which the intensity of the greater sound exceeds that of the lesser. It should here be mentioned that the Capac Company supply two reproducers of the type already described having different degrees of sensitivity, as well as a special form used for locating and comparing external sounds, such as those produced by valve mechanisms, gearing, universal joints or even by gases escaping from leaky pipes, &c. For investigating sounds of this character, the reproducer employed is provided with a conical inlet resembling that of a telephone transmitter, and the sound waves collected in this are concentrated and directed on to a thin diaphragm of mica. The connection from the back of the reproducers to the ear tubes is the same as that used for reproducers of the type previously described.

The recent development referred to in the early part of this article is the provision, for comparison purposes, of an independent source of sound, the intensity of which can be varied over a wide range. The sound source, which comprises an electrically-operated interrupter and two sounders having different degrees of sensitivity, is connected to the ear pieces together with a reproducer for either internal and external sounds, so that the user hears the sounds from the source and the reproducer simultaneously. The former is then increased in intensity by moving a knob attached to a scale until the sound introduced is just sufficient to drown the sound from the reproducer. The scale reading is then a measure of the intensity of the sound transmitted through the reproducer. The range of the apparatus, however, is greatly extended by the provision of valves similar to those above referred to, so that if the intensity of the sound received is above the range of the sound source, the former can be reduced as required. Very weak sounds on the other hand, can be dealt with by partially cutting off the artificial sound by means of the other valve. In some cases, particularly when continuous and more or less uniform sounds are being investigated, it has been found preferable to make a test by adjusting the artificial sound, so that it can only just be heard in addition to the machinery sound. It should also be mentioned that provision is made for varying the pitch of the artificial sound without altering its intensity; by this means the occurrence of beats can be avoided and two similar sounds can be more readily distinguished. After a test has been completed, the valve positions, scale readings and test conditions may be recorded on a log sheet and retained for future reference. It is thus possible to compare a later machine with one previously delivered, provided that the volume of sound produced by the instrument remains constant for any given scale reading; we are informed that this is the case for at least a year.

The apparatus, which is easily portable, being contained in three small cases, is provided with two sets of ear tubes so that two persons can listen simultaneously while a test is being made. This feature is obviously useful when the apparatus is being used, as it may very well be, to settle a dispute with respect to the noise of machinery. In the above brief description we have only mentioned a few of the possible applications of the apparatus. Doubtless other applications involving the practical measurement and comparison of sounds will occur to our readers, and in any case it may be useful to know that simple and convenient means for carrying out such tests are available when required.

THE PRESERVATION AND RESTORATION OF H.M.S. "VICTORY."*

Notes on the Preservation of H.M.S. "Victory" and Her Restoration to the Trafalgar Condition.

By Sir PHILIP WATTS, Hon. Vice-President.

IN 1905, the centenary of Nelson's last battle, I contributed to our Transactions, at our summer meetings, a paper entitled "The Ships of the Royal Navy as they existed at the time of Trafalgar."

That paper necessarily dealt with the ships of the Navy considered as a whole. Not much space was available for particulars relating to individual ships. I was, however, able to make some special reference to the Victory.

On my return to the Admiralty in 1902, I discovered the original sheer and profile drawing of the vessel. It had become much dilapidated, but I was able to have it fairly well restored. I exhibited this restored drawing at the reading of my paper and included a small-scale copy of it in the illustrations accompanying the paper. I also stated, among other things, that she was launched in 1765 and, in spite of long years of arduous active service. "At the present moment, however, the Victory is the flagship of the Commander-in-Chief at Portsmouth, and is in good repair. A large quantity of the timber damaged in action and decayed has been removed from time to time, but much of the old vessel yet remains."

What I am saying in the present notes must be considered as being in large part a continuation of what I said in my 1905 paper.

Nearly twenty years have elapsed since I made the above statement respecting the condition of the Victory. Meanwhile the effects of time have weighed very heavily on her. It is no longer true that she is "in good repair." She is in fact very far from that condition. During the intervening years decay has at last set in so rapidly and so extensively that in order to avoid the risk of her foundering at her moorings she was taken into dockyard hands, had most of her ballast removed, and was, in January, 1922, placed in No. 2 Dry Dock at Portsmouth, where she now lies, and is intended to lie as long as skill and loving care can keep her intact. She is supported partly on her keel and partly on strong steel bilge crutches. She is shored as usual from the sides of the dock and for the time being is entirely free from danger of collapse. She is still the flagship of the Commander-in-Chief at Portsmouth, and it is still true that much of the material of the old vessel remains. An earnest appeal, largely based on the eminence of those officers who, long ago, carried their flags on her and the great deeds wrought by her in battle, is being made for the preservation and restoration of the vessel. This side of the question, however, is scarcely one for the Naval architect as such.

Dealing with that side of the matter specially interesting to naval architects we find here a vessel launched in 1765, having fought for many years in line of battle, continuing on active service for ten years thereafter, kept in commission ever since, in good repair in 1905 and still strong enough in 1922 to bear the strains incidental to docking. This longevity is not only extraordinary but is, I think, without parallel.

Cases of the great longevity of some wood vessels are on record. For instance, the Sovereign of the Seas, built at Woolwich in 1635, is one such. The Endeavour, Captain Cook's ship in his first voyage to the South Seas, is also reputed to have had an extraordinarily long life. There are others not necessary to be specifically mentioned herein. I think, however, that the long life of the Victory is quite unique.

The conditions which made for longevity in wood ships were never thoroughly understood. Scientific investigations were being made in the middle of the last century, but, before a satisfactory conclusion was reached the necessity of such investigations entirely disappeared owing to the advent of iron and steel as materials for ship construction.

As an instance of the want of real knowledge of the conditions necessary for longevity I may mention that in the winter of 1868–69 there was broken up in No. 4 Dry Dock at Portsmouth the two-deck wooden line-of-battle ship Superb. In the adjacent dock, No. 3, was a wood-built steam frigate Glasgow which had not previously been outside Portsmouth Harbour except to make in the early part of 1862 a steam trial, in an unmasted condition, in Stokes Bay. In 1868–69, many of the timbers of Glasgow were so decayed that they were removed and replaced by perfectly sound wood taken from the Superb.

In spite of the want of knowledge of the conditions necessary to secure longevity, these conditions somehow, and apparently largely of their own accord, conspired together to preserve the Victory for us to this day and in a condition making it readily practicable to preserve her for many years to come and to leave undisturbed a considerable portion of the existing material in her. As a piece of practical wood shipbuilding, I hope that some day some one will trace out what may be called the life history of the structure of Victory, dealing with all matters bearing on her repair from time to time and her exceptionally long life.

Any scheme for the preservation and restoration of the vessel must necessarily be founded on a knowledge of her condition, at present. Such a scheme also obviously involves a close consideration of the amount of money available for the purpose.

I have been appointed by the Society for Nautical Research to act as chairman of a sub-committee to consider what steps shall be taken to reserve the ship and to restore her approximately to her condition at the Battle of Trafalgar.

In this capacity I have made a survey of her and have forwarded an interim report relating thereto to Admiral-of-the-Fleet Sir Doveton Sturdee, Bart., G.C.B., the president of the Society for Nautical Research, the body interesting itself in obtaining funds for the preservation and restoration of the Victory. With Sir Doveton's permission I give hereunder a copy of this report.

RESTORATION OF H.M.S. "VICTORY."

An Interim Report from Sir PHILIP WATTS, K.C.B., F.R.S., late Director of Naval Construction, Admiralty, and chairman of the Technical Restoration Committee.

"A recent survey of H.M.S. Victory in dry dock at Portsmouth shows that while the ship has successfully withstood the strain to which she has been subjected in Portsmouth Harbour caused mainly by the variation in the distribution of buoyancy and weight, there is no question that the condition of her underwater timbers and framework is such as to preclude all possibility of reballasting her for further service afloat. In fact, had she not been dry-docked, she would have been in danger of sinking at her moorings.

"It is evident, however, that the structure of the vessel (in spite of the decayed condition of her timbers and much of her planking) with a properly-devised and executed scheme of repair and restoration, could be brought into a condition in which it would be able, for many years to come, to bear all the strains that would be brought upon it in the vessel's present snug berth in dock.

"Although no important change of form took place in the vessel during the removal of the ballast and docking, she has in the course of her long service become considerably 'hogged'; *e.g.*, the bow from the foremast to the stem has drooped about 18 in., and the stern abaft the mizen mast about 8 in.; the decks visibly follow the distortions. The droop forward was probably caused by the weight of the moorings, and the strain brought about by the vessel swinging in the tideway over a period of so many years.

"The sides at and below the waterline are much decayed—the sides above the waterline, including inside and outside planking and timbers, are in much better condition; the decks generally and the beams and shelves supporting them are in fairly good condition, although in places the decks are much worn. The sides above the waterline, with the waterways, shelves, &c., will constitute strong girders which, when adequately supported by pillars and shores will carry the decks and all upper parts of the vessel, as well as the sides and hull below the waterline to the turn of the bilge. The pillars and shores must be continued down from deck to deck, and to the floor of the dock; and as the work of restoration proceeds it will be desirable further to support the vessel by fitting longitudinal bilge blocks on each side of the middle-line keel blocks, near the heads of the floor timbers.

"The chief features to be considered in the restoration are the masts, yards, rigging and the finish of the bow, stern, and topsides. These, with the renewal, where necessary, of the defective timbers and the addition of the necessary fittings to bring the vessel to her Trafalgar conditions will entail heavy expenditure.

"With regard to fittings—the interior of the vessel

* Paper read at the Institution of Naval Architects, March 21, 1923.

has been altered from time to time (apart from the structural features), cabins, store-rooms, mess-tables, &c., such as existed at Trafalgar will have to be added. Shot racks will have to be fitted round each hatchway and elsewhere as was usual; the ship's cooking galleys must be reproduced and the steering wheel and tiller fitted with raw hide ropes of the old pattern. A complete set of boats will be required and the anchors with their stowage arrangements should be installed.

"Detailed specifications will, of course, be required, but this brief outline report is perhaps sufficient to indicate what will be involved in bringing the vessel into a condition approximate to that at Trafalgar."

Vice-Admiral Sir Richard Phillimore, K.C.B., &c., has also considered the matter of restoration of the Victory and reported thereon through the Commander-in-Chief, Portsmouth, to the Admiralty. The Admiralty has kindly forwarded a copy of this report to Sir Dovetон Sturdee. A full statement of the correspondence on this subject appears in the Journal of the Society for Nautical Research, in the issue of the *Mariner's Mirror* for July, 1922.

The Admiralty has undertaken to carry out, at its own cost, out of public funds, a considerable amount of work for the preservation and maintenance of the vessel as distinct from her restoration to Trafalgar conditions. Much of this work has been done and still some is in progress. The Admiralty has further stated that it will sympathetically execute any well considered scheme of restoration proposed by the society for Nautical Research, if the cost of the same be provided by public subscription, so as not to fall on Parliamentary Votes, as the present state of the national finances will not admit of this being done.

It is estimated that at least 150,000*l.* will be required to effect such a restoration as is desired. More than 50,000*l.* is now in hand, and the work of restoration will be at once commenced. The reconstruction of the internal arrangements of the decks as regards guns, mess-tables, cabins, &c., will take place later. The reconstructions of the masts, yards and rigging will also be deferred for a time.

The Victory was designed and built in what many call the dark ages of naval architecture in this country, but in spite of this we have here a noble vessel, noble in herself, of very graceful proportions and form, a vessel almost miraculously preserved to us and noble also in the associations and traditions bound up with her. She was fast and weatherly in comparison with others of her class, and was much desired both as regards a captain's command and as a flagship. She had originally a most beautiful bow and stern much admired and beloved by all marine artists. Some of the beauty still remains, but much has disappeared as the result of changes made from time to time. It is necessary that the original beauty of the bow and stern shall be restored, and this will be one of the first works of the restoration.

It remains for the present generation of naval architects to bear their share of the cost of restoration of the Victory, the creation of their ancestors and fellow-craftsmen of long ago. If the present opportunity be not utilised it must be borne in mind that no such opportunity can possibly recur. There is no other vessel having such a history as that of the Victory, or even approximating thereto. Let each and all of us do our best to secure for many years to come for ourselves and those who come after us the maintenance of this noble vessel in a condition as far as practicable that in which she went into action at Trafalgar.

THE INSTITUTION OF GAS ENGINEERS.—The annual general meeting of this Institution will be held in Belfast from June 26 to 29. The programme will include the reading and discussion of papers, and the presentation and discussion of reports. A lecture, a reception, visits to various works, an excursion, and other social functions are contemplated.

USE OF WIRE SAW IN QUARRIES.—The wire saw has been used with success in marble quarries, both in America and elsewhere. It usually consists of a three-strand endless wire rope about ½ in. in diameter. The wire passes around a driving wheel and is carried on pulleys to the place in the rock where a cut is desired. An abrasive, such as steel shot, with water, is fed to the rope at the point where it enters the rock. To prevent too rapid abrasion of the wire, a length, sometimes exceeding a mile, of wire rope is used. The wire saw may be used for making cuts in the quarry or to saw blocks on the bank. This type of equipment has, however, never been used in slate quarries in the United States, nor, from information available, does it appear to have been used in slate quarries in other countries.

CARBON MONOXIDE RECORDER.—Work of the United States Bureau of Mines on the ventilation of vehicular tunnels has developed the need of an instrument to record continuously carbon monoxide over a range of concentrations up to about 10 parts in 10,000. For this purpose an instrument has been designed at the Pittsburgh, experiment station of the bureau, using multiple, differential thermocouples with a catalyser between the junctions to cause carbon monoxide to combine with oxygen of the air. The heat of reaction produces across the thermocouples a potential difference which, as a measure of carbon monoxide concentration, it is proposed to record with a recording potentiometer. When the instrument is set up it will be calibrated with known mixtures of carbon monoxide in air. If it proves practicable, the instrument will also be useful around mines, blast furnaces, metallurgical and chemical plants, or wherever carbon monoxide creates risks.

THE MAZOE IRRIGATION DAM.*

By MARK RANDALL, Assoc.M.Inst.C.E.

THE Mazoe River Valley in Southern Rhodesia forms the chief centre of the operations of the British South Africa Company for establishing irrigated agricultural estates. The valley extends from the dam site at the Poort, 24 miles due north of Salisbury, to the Shamva gold mines, covering a watershed of 900 sq. miles. In 1919 the European holdings in the valley amounted to 3,000 acres, chiefly devoted to mealie growing. The profits resulting from this depend on weather conditions, and the ground lies fallow for eight or nine months in the year. An irrigation system will allow different crops to be grown in rotation, giving a greater return from a smaller cultivated area.

In 1912 a syndicate constructed a weir and canal to irrigate several hundred acres of citrus groves. The normal flow of the river proved insufficient to serve more than 50 acres, however; and in 1914 the British South Africa Company, which had taken over the concern, embarked on a comprehensive programme, including the construction of a dam and a distributing system, and the extension of the irrigated area to 4,000 acres.

Hydrographic Data.—At the Poort the river has a catchment area of 130 sq. miles, with altitudes of 4,800 ft. above sea-level at the head waters, and 4,040 ft. at the Poort. The conformation consists of grass flats in red schist soil to within 6 miles of the dam; from this point steep granite hills emerge into the kopjes forming the flanks of the Poort. Hydrographic records dating from 1912 obtained at the Cleveland dam provided a basis for the estimation of corresponding data at Mazoe. Records of rainfall at Salisbury from 1897 have been used to estimate the rainfall at Mazoe from 1897 to 1910, before which date no records were available at the latter place. The average fall is given as 33·4 in. per annum, with a maximum and minimum of 55·76 in. and 22·65 in. respectively. Tables of discharge at Mazoe for the period 1917–20 show that, until 18 in. to 20 in. of rain—the saturation figure—has fallen, the intensity of the rainfall has only a minor influence on the discharge. The evaporation at Mazoe is estimated from records obtained at Cleveland with an evaporating pan, and is allowed for at the rate of ⅓ in. per diem from August to December and ¼ in. per diem from January to July.

Site.—As a result of a contour survey carried out in 1914–15, the present site was chosen from among six or seven considered. Trial holes and shafts showed that the banks and foundations consisted of a massive grey, finely crystalline rock composed essentially of quartz and carbonite—probably an altered acid igneous rock known as "felsite." The ironstone overlying the felsite, though sound, was fissured by numerous open horizontal cracks. As excavating down to the felsite and rebuilding in concrete or masonry would have involved prohibitive expense, it was decided to build a solid arched concrete dam on the ironstone, sealing the fissures in the latter by the François cementation process.

Reservoir.—The flank spillways are designed to give a maximum rate of discharge of 20,000 cusecs with a corresponding rise in the surface level of 5 ft.; the maximum flood recorded is 10,000 cusecs for 5 hours. An average annual rainfall of 30 in., with a 9 per cent. discharge, thus yielding 18,700 acre-ft., were adopted as mean values. The spillway crests were placed at R.L. 4,130, *i.e.*, 90 ft. above the lower outlet culverts and 98 ft. above the lowest foundation level. With the water at R.L. 4,130 the capacity of the reservoir is 17,500 acre-ft., the surface area being 790 acres; the corresponding figures for R.L. 4,140 are 26,700 acre-ft., and 1,100 acres.

Cementation.—Drilling was carried out with steam-driven Sullivan "H" or Beauty "E" drills. Percussion rock drills proved unsatisfactory, and diamond drills, with crowns 1¾ in. to 2¾ in. diameter were used. The cementation pumps had 14-in. steam cylinders, 1¾-in. rams, and a 12-in. stroke. The ratio of cement to water used was 3 : 100. Before cementation was commenced at any hole, water was pumped in under increasing pressures up to 100 lb. per square inch to clear the crevices and to show where water would issue from the exposed formation. Any points of leakage were caulked, and the hole was plugged with clay for two-thirds of its depth to confine the preliminary cementation to the surface of the ground. The first stage of the process was then carried out by continuous pumping at a low pressure for a day or two. After an interval of several days the hole was re-drilled and only one-third of the clay plug was left in. Cementation was then carried out at a higher pressure, since the upper layer of treated rock acted as a capping. Finally the third or fourth stages were carried out similarly. Pressures ranged from zero to 1,750 lb. per square inch, and the pump strokes per minute, from 30 to 80. Cementation was continued from June to November, 1918, and from May to September, 1919. The linear distance drilled through was 3,166 ft. and 360 tons of cement were used, the net cost of the operation being 10,000*l.*, or 8*s.* per cubic yard of rock treated.

Construction of the Dam.—In the main wall concrete blocks capable of being deposited by the masons were used, instead of shuttering; the latter, however, was employed on the spillways. All concrete faces and blocks exposed to water were of 4 : 1 mixture to a depth of 1 ft. 6 in., while the hearting was of 6 : 1 mixture. No plums were used. Concreting was carried out from November, 1918, to March, 1920. The net cost of the dam, including cementation was 132,258*l.* The principal dimensions are: Radius of arch, up-stream face, 180 ft.; chord, 252 ft.; crest level, 4,135·2; lowest foundation level, 4,032·0. Particulars of the cross-section of the dam wall are: Width of crest, 10 ft.; width at R.L. 4,110, 10 ft. From this level downwards the down-stream face has a 1 : 3 batter. The up-stream face is vertical.

Leakage.—When the water-level rose, 12 main points of leakage were observed. Salt tests were carried out to discover the points of entry in the basin, and the position and discharge of leaks were recorded from time to time. When the water-level reached 4,129 for the first time, the total observed leakage was 4·20 cusecs, but subsequent observation showed steady decrease.

* Abstract of a paper read before the Institution of Civil Engineers, on March 20, 1923.

THE IMPROVEMENT OF THE WATER SUPPLY OF HOBART, TASMANIA.*

By JOHN CLARK ROSS, M.Inst.C.E.

IN 1912 the water consumption of Hobart during the summer season was over 2,000,000 gallons per day, the population being nearly 35,000. The supply was obtained from streams and springs arising on the slopes and table-lands of Mount Wellington; this was conserved in two reservoirs of 40,000,000 gallons and 60,000,000 gallons capacity, about 3 miles from the centre of the town.

During the summer months, especially in dry seasons, difficulty was found in keeping up a full supply. In view of the steady increase of the population in the city proper, and the inclusion in the water area of adjacent municipalities, it was decided to build a new conservation reservoir and to construct a larger intake main. The site for the new reservoir was chosen at Ridgeway, about 4 miles from the town, at an elevation of 900 ft. above sea level. The concrete dam wall was of composite design, having two gravity wings with an arched centre portion. The leading dimensions of this dam are as follow:—

	Ft.	In.
Length of west wing (gravity wall)	293	7
Length of arch	232	9
Length of east wing (gravity wall)	203	4
Total length of dam	729	8
Radius of arch	200	0
Depth of arch—top to foundations	201	0
Depth of arch—to bottom of fault	285	0
Top width of wall (below coping)...	6	0
Water area when full	19 acres.	
Maximum depth of water	95 ft.	
Capacity (full)	207,371,500 gallons.	
Height above sea-level: T.W.L. ...	905 ft.	

The work was begun under a contract, which was later determined; and the construction was then carried out departmentally. Very considerable difficulty was found in getting a sound foundation in the deepest part of the arched portion, although the site was examined by shafts and tunnels, all in rock, previous to the designing of the wall. At one place the excavations for the wall were carried to a depth of over 180 ft. below ground-level. The wings and arch are built independently of each other, and the joint is sealed with a 6-in. by 6-in. bitumen tongue protected with sheet lead on each side. The arched portion of the wall is reinforced for about two-thirds of its height with 40-lb. rails, placed vertically and horizontally, to form a grid of 5-ft. mesh. All concrete was machine-mixed and was placed *in situ* mostly by shoots from elevating towers, the remainder being deposited by skips on an 800-ft. span "flying fox." The total cost of the work, including the outlet-tunnel valve-tower, &c., was 116,500*l.*

In order to supply Ridgeway reservoir, a new main was laid from the headwaters of the North-West Bay River on the slopes of Mount Wellington—a distance of about 9 miles, of which about one-half was laid with 15-in. and the other half with 18-in. piping. This pipe line and the discharge pipe from Ridgeway to the distributing basin, also 15 in. diameter, as well as the mains from the distributing basin to the lower reservoirs and city connections—a total length of about 10½ miles—were intended to be of cast-iron or steel; but owing to the high prices then ruling, they were laid instead with centrifugally-made reinforced-concrete pipes, which have proved thoroughly satisfactory. The 15-in. and 18-in. supply mains were designed and tested to 75 lb. per square inch when laid, and the 15-in. line, from the reservoir to the distributing basin, to 130 lb. per square inch. The substitution of concrete for iron pipes effected a saving of more than 60 per cent., the lowest price for iron being 28,824*l.*, exclusive of cartage and laying, while the concrete line cost 13,624*l.*, including the cost of cartage and laying. The process of manufacture of reinforced-concrete pipes is described, and different types of joints are discussed. Tables are also given of the results of internal and external tests of pipes of various diameters and weight of reinforcement. Attention is drawn to the many situations in which these pipes may be usefully and economically employed, and observations are made as to conditions which call for particular care in the use of them.

* Abstract of paper read before the Institution of Civil Engineers, on March 20, 1923.

THE WATER SUPPLY OF THE CITY OF CAPETOWN.†

By DAVID ERNEST LLOYD-DAVIES, M.Inst.C.E.

THE principal municipalities within the boundaries of the peninsula of the Cape of Good Hope having combined in 1913 under a single administrative body, the newly-formed council decided that the augmentation of the water supply needed immediate attention. Before the

† Abstract of a paper read before the Institution of Civil Engineers, on March 20, 1923.

APPARATUS USED BY THE STEAM-NOZZLES RESEARCH COMMITTEE.

Fig. 1. CAGE IN MANCHESTER NOZZLE-TESTER.

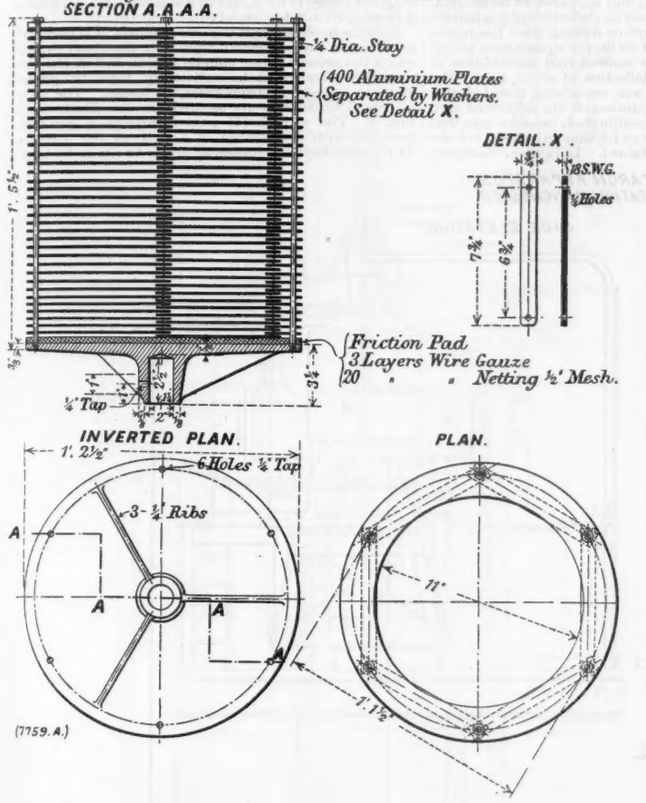
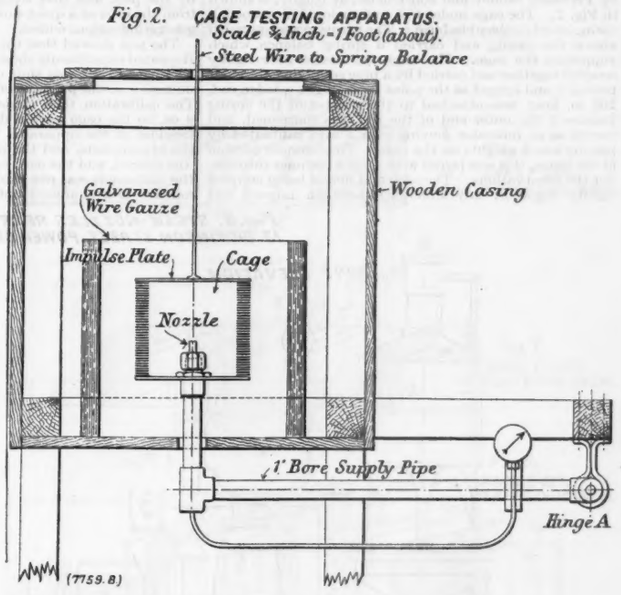


Fig. 2. CAGE TESTING APPARATUS. Scale ¾ Inch = 1 Foot (about).



unification the combined yield from various sources was 4,750,000 gallons per diem—an inadequate quantity for a population of nearly 200,000. (The present average summer consumption is nearly 7,250,000 gallons per diem.) On the recommendations of a committee consisting of Messrs. W. A. Tait and Thomas Stewart, MM.Inst.C.E., and the author, it was decided early in 1917 to provide an entirely new supply from Steenbras.

The Steenbras Scheme.—The catchment area, 23⅛ sq. miles in extent, is situated 40 miles from the city, and its elevation ranges from 1,050 ft. to 4,150 ft. above sea-level. It is drained by the Steenbras and Kogel Berg Rivers, the confluence taking place in a natural basin, which was suitable for the erection of a dam across the narrow neck through which the main stream originally flowed. In the neck the water falls 1,000 ft., through a gorge ¾-mile long, directly to the sea. It is estimated that the daily yield in dry years will be 25,000,000 gallons. The average annual rainfall for 1916–21 inclusive is 45 in., and the ratio of discharge to precipitation is 71 per cent. The average annual evaporation is 80 in., and the average temperature in the valley for the year is 64·5 deg. F. An additional supply of 5,000,000 gallons per diem was considered sufficient for ten years' development of the city, and, in view of the urgency of the scheme, this quantity was adopted as a basis for the design of the reservoir.

Reservoir.—A capacity of 600,000,000 gallons is required to balance the discharge from the watershed during a drought of 210 days. The ultimate capacity of the valley is ten times this quantity, and the most favourable site for a dam was left free for the building of a larger wall in the future. The present dam is arched in plan and built in a trench in sandstone. The developed length of the dam on the up-stream face is 900 ft.; radius of the arch, 250 ft.; chord, 363 ft.; and the maximum depth of the trench is 20 ft. The maximum width at the base is 38 ft., tapering to 8 ft. 6 in. at the crest, and the maximum height is 62 ft. The spillway crest is 240 ft. long. The highest impounded water-level is 1,090 ft. above sea-level, and the lowest draw-off is at elevation 1,060. The dam is built of cyclopean masonry, the plums being embedded in 6 to 1 concrete, and is faced with concrete blocks. A contract for its construction and completion in two years was signed in December, 1917, but in the middle of 1919 this contract was terminated and the work was completed by direct administration. The sluice was closed finally in October, 1920. To convey the water from the reservoir to the commencement of the pipe line a tunnel, 2,648 ft. long, had to be driven. Certain portions of this gave trouble through inrushes of water and sand through fissures up to 8 ft. wide in soft portions of the sandstone. This was overcome six months after the fissures were struck by approaching gradually with a series of bulkheads. Where the rock is soft the tunnel is lined with cement concrete, which is heavily reinforced over the fissures. Where the rock is hard a dished concrete invert alone has been used.

Pipe Line.—From the tunnel portal (elevation 1,051) the water passes through 24-in. and 18-in. cast-iron pipes to two 50,000-gallon break-pressure tanks at elevations 625 and 352, and thence to the 30-in. cast-iron pipe line leading to the lower service reservoir (elevation 189). This line is 39 miles 2,161 ft. long. An additional 576 ft. leads to the Molteno service reservoir (elevation 313), the net hydraulic gradient being 1 in 5,364. The test values of the pipe line, after twenty months' service, are 6,780,000 gallons and 3,400,000 gallons per diem at the lower and Molteno service reservoirs respectively. The maximum static head on the line is 352 ft., and the thickness of the pipes ranges from $\frac{5}{16}$ in. to $1\frac{1}{16}$ in. As the light pipes suffered damage in transit, a minimum thickness of $\frac{11}{16}$ in. was adhered to later. Laying was commenced in February, 1919, and completed in January, 1922.

Discharge.—Owing to delay in the delivery of Venturi meters the pipes had been in use for nine months when readings were first taken in December, 1921. The pipes, however, were still clean. During 1922 a diminution of discharge of 5 per cent. was observed. The discharge computed by various formulas is compared. In connection with the loss of discharge through incrustation the author deduces from various sources the following value of the percentage loss of discharge :—

$$e = \left(\frac{1 \cdot 26}{q^{2 \cdot 23}}\right) t^q,$$

where t denotes the time of use in years, and q is a constant ranging from 0·3 to 0·9.

Water was supplied to Cape Town by the new line in January, 1921, the total expenditure being 1,176,400*l.* for the whole work.

FIRST REPORT OF THE STEAM-NOZZLES RESEARCH COMMITTEE.*

Formation of the Committee.—This committee was formed in 1914 by the Council of the Institution of Mechanical Engineers :—

"To report upon what experiments relating to the subject of 'The Action of Steam passing through Nozzles and Steam Turbines' could with advantage be undertaken.

After carefully reviewing the various ways in which the efficiencies of nozzles can be obtained, it was felt that the measurement of the impulse of a jet of steam issuing from a nozzle upon a pressure-plate would lead to the most reliable results. Two forms of apparatus were considered :—

(*a*) A simple nozzle-testing plant which consisted essentially of a nozzle-box arranged to bolt on to the top of a discharge-box or chamber. Near the bottom of this chamber a pressure-plate was arranged to measure the impulse of the jet, and a supporting pin for this pressure-plate was passed through a frictionless gland to the weighing lever below.

(*b*) An apparatus for comparing various nozzles with a standard by the differential method, by means of bucket resistance poised on springs.

It was thought that both designs of apparatus would ultimately be required, though up to the present only the first or non-differential type has been made. Mr. H. M. Martin is chiefly responsible for the design of this apparatus.

Measurement of the Impulse of the Jet by Means of an Impact Plate.—The jet is caused to impinge normally upon a plate, which deflects it through an angle of 90 deg., so destroying the momentum of the jet in the direction of its original motion. The plate forms one side of a balance which weighs the jet impulse (F), and the velocity of the steam (c_m) is then determined from the relation $c_m = \frac{F\,g}{m}$, where m is the measured discharge per second and g the acceleration due to gravity. This method was used by Delaporte,* who shrouded his jet to overcome the apparent anomalies between the impact and reaction methods. It is the one adopted in the present research.

Impact and Reaction Anomalies.—Both methods consist of a direct measurement of the jet energy, and should give essentially equal results. Until the Manchester apparatus was designed it was found that the results from the two methods were inconsistent with each other; also that the impulse varied with the distance of the plate from the nozzle, even without clearance expansion. Mr. T. B. Morley (*loc. cit.*) carried out comparative experiments and concluded that the reaction results were the more exact. This was the general view. Two factors were considered to be responsible for the anomalies—the jet on leaving an impact plate appeared to cause a slight depression of pressure on the underside of the plate, which might introduce an important error if the plate were large. The motion of the jet appeared also to induce a vortex co-axial with the jet by means of which some of the surrounding medium was entrained into the jet and carried to the plate. The effect of both these actions is to increase the measured impulse and to give values of velocities which are too high.

Apart from this difficulty, the Steam-Nozzles Committee decided that the impact method of measurement was the more practical. Reaction apparatus confines experiment to relatively small quantities of steam; otherwise the mass of the supply pipe and nozzle system introduces friction effects which detract from the accuracy of the experiments. It is possible with impact apparatus to make all steam connections rigid and to reduce mechanical friction to a negligible value; the problem before the committee was to design some form of impact plate to overcome the measurement anomalies. This problem has now been solved. Instead of a plate, a cage is used, built up of thin strips of metal separated by thin washers, and carried on the plate proper, which is in addition faced with layers of wire mesh and a layer of fine gauze. Fig. 1, above, shows the actual cage in use in the present tests. The intention of the design is to cause the steam to leave the cage at a low velocity, and entirely at right angles to its original direction of motion.

* Abstract of the report published in the Proceedings of the Institution of Mechanical Engineers, January, 1923.

* Delaporte. "Measuring Efficiency of Diverging Nozzles by Pressure Plate." *Revue de Mécanique*, vol. x (1902), page 466.

This cage has been evolved, as the result of experiments by Mr. H. M. Martin and Mr. F. Samuelson.

The test apparatus for these experiments, suggested by Professor Stoney and constructed at Rugby, is shown in Fig. 2. The cage under test was enclosed in a wooden casing nearly cubical in form. The corner posts extended above the casing and carried a spring balance which supported the cage. The cage and nozzle were rigidly coupled together and carried by a pipe supplying air under pressure, and hinged at the point A. A light wooden rod, 20½ in. long, was attached to the pointer of the spring balance; the outer end of the rod was sharpened, and served as an indicator moving over a card calibrated by placing small weights on the cage. To eliminate friction at the hinge, this was jarred with a light hammer throughout the observations. The cage and nozzle being coupled rigidly together, any difference between impact and reaction was shown by a movement of the system on opening the valve supplying air to the nozzle, and the measurement of this difference was given by the reading on the calibrated card.

In earlier tests various forms of cage were tested, but always without the present facing of wire mesh, &c., on the plate, and although the difference between impact and reaction was found to be less with the cage than in previous tests with a plate only, there was still a sufficiently serious discrepancy. The conclusion was reached that the most promising plan would be, not only to destroy the momentum of the jet in the direction of its original motion, but also to reduce its velocity in any direction to a minimum before permitting it to leave the cage. There would then be no energy available for maintaining the eddies, which appeared to be responsible for the anomalies. For this purpose the plate was faced with 20 layers of wire netting, arranged "criss-cross" and a single layer of felt; the netting had a mesh of about ½ in., and the wires a diameter of about 25 mils. The cage was built up upon this, and the whole tightly clamped together. The facing formed a sort of porous pad on to which the discharge of air from a ¼-in. nozzle was directed. The layers of netting broke up the jet and the layer of felt prevented the air from passing easily along the smooth surface of the plate. The intention was that most of the kinetic energy of the jet should be converted into heat by the frictional resistance occasioned by the pad, and that the air should accordingly escape from the cage as a quiet slow-moving stream, incapable of generating serious eddies.

The test showed that this end appeared to be secured. Repeated experiments showed no deflection of the pointer whether the air was shut off or flowing from the nozzle under an initial pressure of 70 lb. per square inch gauge. The calibration then made showed that an addition of 8 oz. to the cage gave a deflection of about ¾ in. The freedom of the apparatus was repeatedly tested during the experiments, and the position of the calibrated card was altered, and the card recalibrated, to make sure that the null result was not due to friction anywhere, but the null result was always obtained. It is seen, therefore, that the discrepancy problem is solved, and that it is possible accurately to measure the impulse of a jet. For the steam experiments, the felt is replaced with wire gauze, and necessary allowances for the dimensions of the jet are made.

Description of the Nozzle-Testing Plant.—The nozzle-testing plant described below, and illustrated by the accompanying figures, has been constructed under the direction of the Steam-Nozzles Research Committee of the Institution of Mechanical Engineers, and erected at the Manchester Corporation Power Station, Dickinson-street. The design is chiefly due to Mr. H. M. Martin. Fig. 3 shows the general arrangement of the plant. The steam supply is controlled by means of a 2-in. stop-valve A. B is the nozzle-tester, where the steam expands through the nozzles under test, and the impulse of the jet is weighed. The steam is then condensed in a surface condenser C (Winch Contraflo Condenser, lent by Messrs. Richardsons, Westgarth), and the condensate is directed, by means of a tippler D, either into a weighing tank E, or into a waste pipe F. The pressure on the exhaust side of the nozzles can be regulated (above atmosphere) by throttling back at the valve G between the tester and the condenser.

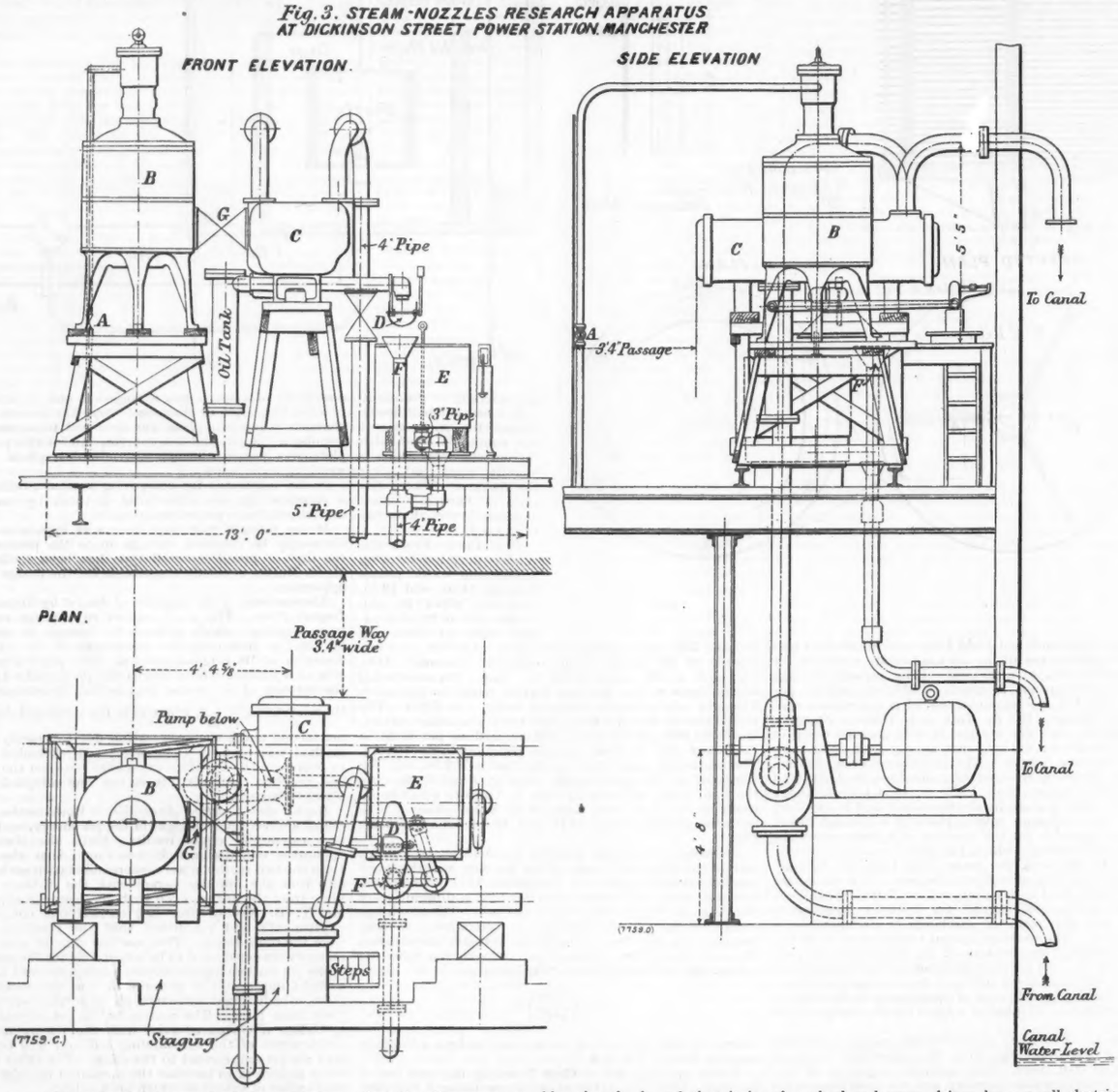
Fig. 4 shows the tester B in section. The nozzle-box (1) is bolted to a nozzle pipe (2), which is of large dimensions compared with the area through the nozzles. The angle of efflux of steam from the nozzles under test is determined by experiment, and the angle of the nozzle-pipe is adjusted to make the jet strike normally on the base-plate of the impulse cage (3). The impulse is transmitted to a weighing lever (4) by means of a steel spindle (5), passing through a frictionless gland (6).

In order to obtain true impulse readings, it is necessary to eliminate any permanent friction in the gland through which the pressure-plate spindle passes, and at the same time this gland must be sufficiently tight to prevent material leakage of steam from the tester. The means by which these ends are secured are also illustrated in Fig. 4. The spindle (5) passes through a gun-metal bush (7) with a clearance of 4 mils on the diameter. The bush is kept in rotation at about 80 r.p.m. by means of a wheel and worm driven by a small electric motor. In this way, with efficient lubrication, all permanent friction is completely eliminated, and the spindle will move to the slightest steady end-thrust. At the same time the viscous resistance of the lubricant between the spindle and the bush acts as a dash-pot damping out vibrations, so that the pressure transmitted to the weighing lever is quite steady. The rotation of the spindle itself is prevented by stop pins (13), as is best seen from Fig. 5, which is a section at Y Y, Fig. 4.

The worm gear and bush are lubricated from the oil tank shown in Fig. 3. Very little oil is necessary, and sufficient pressure is obtained by the use of a bicycle pump connecting with a nipple on the tank. The supply to the working parts is controlled by means of valves in the supply pipes. The supply to the bush is from the top of the spindle when the exhaust pressure, that is, the pressure in the discharge box, is above atmospheric, as in the present tests, but may also be from the lower end of the spindle, as would be necessary if the nozzles exhausted to vacuum.

Cage, Pressure-Plate and Discharge Box.—The cage and plate have already been described above, see Fig. 2. The main feature of the discharge box is its ample capacity which makes it possible to measure the exhaust pressure

Fig. 3. STEAM-NOZZLES RESEARCH APPARATUS AT DICKINSON STREET POWER STATION, MANCHESTER



and temperature with the steam relatively at rest. The function of the wire netting shown at 8, Fig. 4, is to eliminate any eddies which may remain after the steam has left the cage. This netting is not at present in use.

of the hub. The hub (10) is lightly clamped into one of the feet of the discharge box, and forms the fulcrum of the lever.

Balance weights at one end of this lever take the weight of the cage and levers. A scale-pan at this

limits 2½ in. apart.

Programme of Tests.—The present programme covers the following nozzles:—

1. Standard Parsons nozzles: Five nozzles of 1 in. standard Parsons 480 B. blades.

Fig. 4 SECTION OF NOZZLE-TESTER B. (Fig. 3)

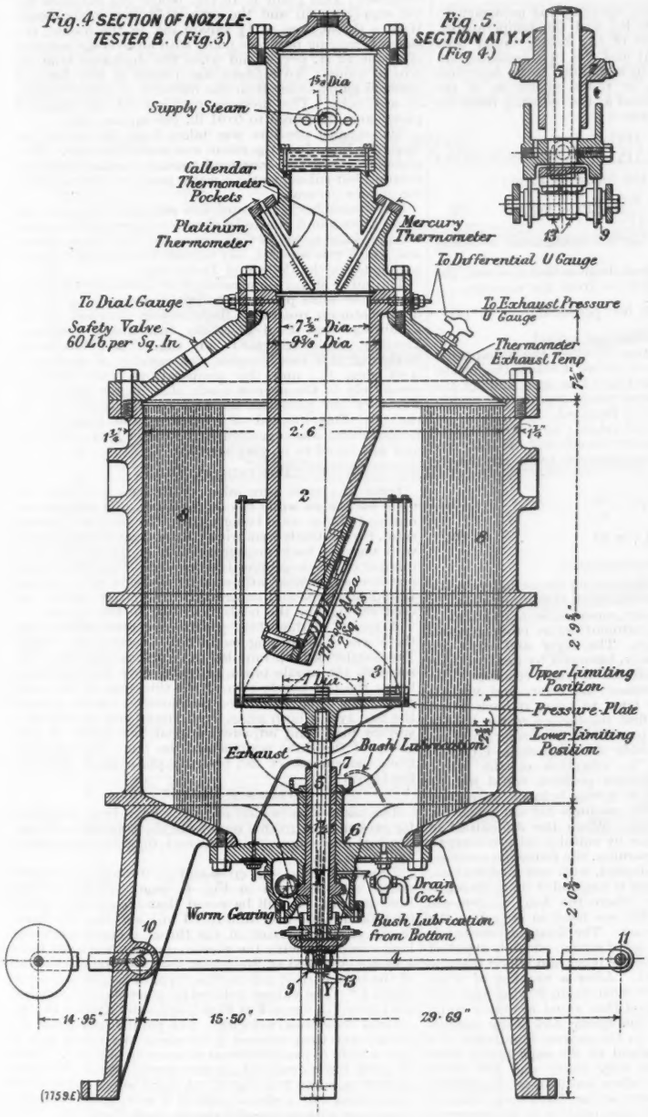


Fig. 5. SECTION AT Y.Y. (Fig 4.)

IMPULSE NOZZLE-BOXES. NOZZLES 2 INCHES HIGH.

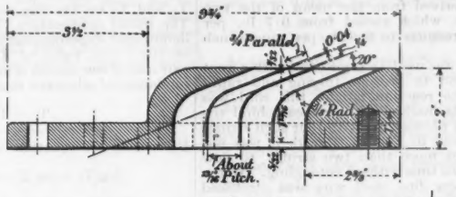


Fig. 6. ANGLE 20°; PLATES 0·04 INCH.

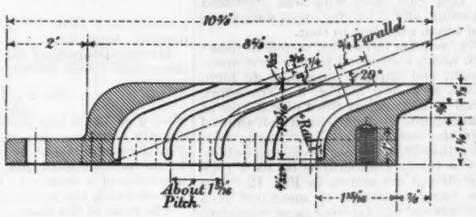


Fig. 7. ANGLE 20°; PLATES 3/16 INCH.

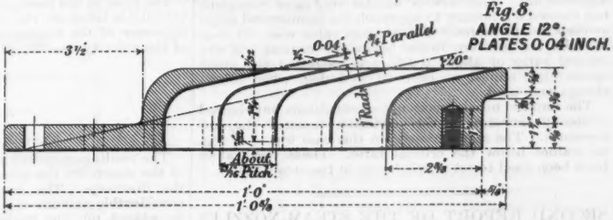


Fig. 8. ANGLE 12°; PLATES 0·04 INCH.

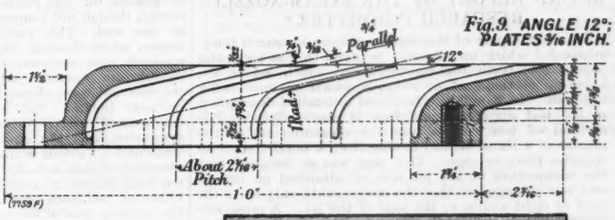


Fig. 9. ANGLE 12°; PLATES 3/16 INCH.

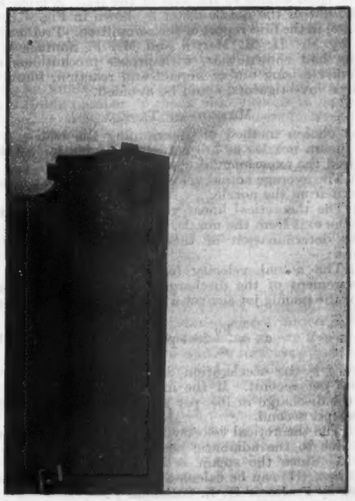


FIG. 11. PHOTOGRAPH SHOWING EFFLUX ANGLE OF STEAM INDICATED BY STRINGS.

Fig. 10. APPARATUS FOR MEASUREMENT OF ANGLE OF EFFLUX OF STEAM FROM NOZZLES.

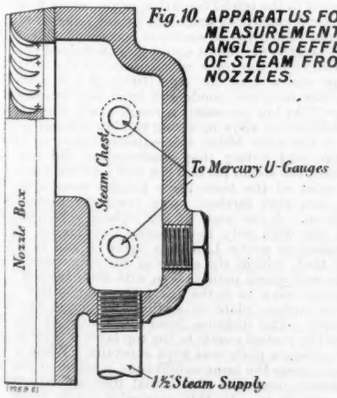
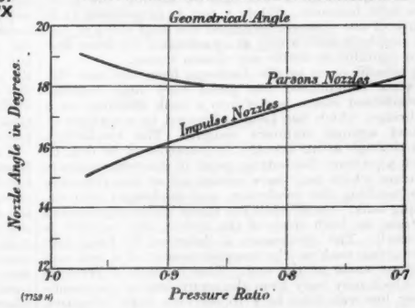


Fig. 12. MEAN ANGLES OF DIRECTION OF STEAM JETS 2½ INCHES AFTER LEAVING NOZZLES.



2. 20 deg. convergent impulse nozzles:—
   (*a*) Thin blades (Fig. 6).
   (*b*) Thick blades (Fig. 7).
3. 12 deg. convergent impulse nozzles:—
   (*a*) Thin blades (Fig. 8).
   (*b*) Thick blades (Fig. 9).

The total throat areas of both types of nozzles have been kept as near as possible the same, and the parallel portions of the impulse nozzles have been made purposely long so that a series of comparative tests can be obtained with varying lengths of throat in this type.

The Efflux angle of the Steam.—In order to determine the correct setting of the nozzle-box in the steam tester, so as to ensure perpendicular impact on the weighing plate, it was deemed advisable to measure the efflux angle of the steam from nozzles when discharging into the open air. For this purpose the nozzle boxes of both reaction

The Weighing Lever.—The weighing lever (4) is built up of two side-bars and three standard bicycle rear hubs (9), (10) and (11). Stop pins (13), in the foot of the pressure spindle, embrace the mid-part of the hub (9), preventing rotation of the spindle, and the pressure is transmitted from the base of the spindle to the flanges

end is then used to measure the impulse of the jet to within a quarter of a pound. The final adjustment is taken on a carefully calibrated spring attached to the other end of the lever (11), which has a stretch of about 7 in. per pound. The distance between the pressure-plate and the end of the nozzle-box can be varied between

and impulse nozzles were bolted on to steam chests about 1 foot in length, and mounted vertically on a 1½-in. diameter steam pipe. The arrangement as set for reaction nozzles can be seen in Fig. 10. The steam pressure was read at the top and the bottom of this steam chest by means of mercury U-tubes, and the atmospheric pressure was measured on an aneroid which had been checked against a Fortin barometer. The pressure ratio was derived from the mean of the two steam chest readings, which varied from 0·7 lb. per square inch at low pressures to 0·5 lb. per square inch at the higher ones.

Fine indicator cord was used, in some cases with a knot towards the outer end to prevent fraying and rapid disintegration. In the reaction nozzles this cord was attached to the points marked with crosses behind the nozzles in Fig. 10. A photograph with four such strings functioning can be seen in Fig. 11, though it was not always possible to get more than two strings to flow in the steam at the same time without entangling. In the impulse nozzles a very fine steel wire was stretched tightly across the opening, and the string, or in some cases a thin metal strip of brass, attached to that.

Two sets of 20 deg. nozzles have been tested to date: 1-in. Parsons 480 B. nozzles arranged to give four openings, each 1¾ in. high, and impulse nozzles, 2 in. high, with very thin plates, as shown in Fig. 6. The efflux angles were measured to the nearest third of a degree of arc from direct enlargements of negatives, which showed the string flowing in the steam-jets. These angles were checked by contact prints from the negatives themselves.

The results of some thirty photographs on each type of nozzle with long strings are shown in Fig. 12. The angle in each case being measured to one-third of a degree of arc. The Parsons' nozzles were more consistent but showed a tendency to approach the geometrical angle at very low pressures. The average value was — 1 deg. 50 min. for pressure ratios below the critical. If the critical ratio of about 0·546 was exceeded the angle opened out almost at once to + 4 deg. when longer strings were used.

The impulse nozzles were not so consistent but showed a steady increase in the deviation towards the low pressures. The average angle in this case was — 3 deg. for values below the critical ratio. These two values have been used to set nozzle boxes in the steam tester.

SECOND REPORT OF THE STEAM-NOZZLES RESEARCH COMMITTEE.*

THE first report of the Steam Nozzles Research Committee (of which an abstract is given in the foregoing pages), sets forth the considerations which led to the adoption of the lines of research which are now being followed. In it will also be found a detailed description of the test apparatus and how it was designed. The method of test chosen was the measurement of the impact of a jet of steam, issuing from a nozzle, upon an impulse plate or cage. This cage was so designed that the momentum of the jet was all absorbed on impact and was arranged so that the steam could only leave the cage at right angles to the axis of the jet. A cross-sectional view of the nozzle-tester is shown in Fig. 4 (page 379 *ante*) in the first report of the committee. Preliminary tests by Mr. H. M. Martin and Mr. F. Samuelson at Rugby, had shown that, with proper precautions, the anomalies arising out of impact and reaction, found by previous investigators, could be avoided.

METHOD OF TEST.

The chosen method of determining the efficiency of such steam nozzles as are actually suitable for turbines required the experimental determination of:—

(*a*) The average actual velocity of the steam at or near the exit from the nozzle.

(*b*) The theoretical linear velocity of the steam at or near the exit from the nozzle.

The determination of these quantities is made as follows:—

(*a*) The actual velocity (c_m) is obtained from the measurement of the discharge (m) and of the impulse (F) of the issuing jet against a pressure plate, the relation being—

$$c_m = \frac{Fg}{m} \text{ feet per second} \quad . \quad . \quad (1)$$

where g is the acceleration due to gravity in feet per second per second. If the impulse is measured in lbs. and the discharge in lbs. per second, the velocity will be in feet per second.

(*b*) The theoretical velocity (c) of the steam is taken as that due to the adiabatic heat drop (DH) through the nozzle. Since the steam is kept dry throughout, the total heat (H) can be calculated from the relation established by Professor H. L. Callendar †:—

$$H = S_0 T + SCP + B.$$

when expressed in foot-lbs. centigrade units this becomes:—

$$H = 0{\cdot}4772\,T - \left(\frac{c' - 0{\cdot}0037}{2{\cdot}2436}\right) P + 464 \text{ lb. cal.}$$

where T = absolute temperature in °C. = 273·10 + t° C.
P = absolute pressure in lb. per square inch.
c' = the co-aggregation volume as given in "The Callendar Steam Tables" (1915 edition), Table IIIc.

$$= 0{\cdot}4213\left(\frac{373{\cdot}1}{T}\right)^{\frac{10}{3}}$$

The adiabatic heat drop in these units will therefore be:—

$$DH = 0{\cdot}4772\,(T_1 - T_2) - \frac{(c_1' - 0{\cdot}0037)\,P_1 - (c_2' - 0{\cdot}0037)\,P_2}{2{\cdot}2436}. \quad (2)$$

To calculate values from this relation it is necessary to know the pressures, P_1 and P_2, and the temperatures, T_1 and T_2 on the two sides of the nozzle under test. The initial temperature (T_1) and the two pressures are determined experimentally in a manner to be described shortly. The value of T_2, or the temperature at the exit side of the nozzle, is arrived at theoretically from the fundamental adiabatic relation—

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{n}{n}}.$$

By writing the equation in the following form:—

$$\log T_2 = \log T_1 - \frac{3}{13}(\log P_1 - \log P_2) \quad . \quad (3)$$

a convenient form for evaluation is obtained avoiding negative logarithms.

Having determined the heat drop in this manner, the theoretical steam velocity follows from the equation:—

$$c = 300{\cdot}2\sqrt{DH} \text{ feet per second} \quad . \quad (4)$$

when $g = 32{\cdot}20$ feet per second per second.

Strictly speaking, this relation involves the assumption that the steam has no velocity before it enters the nozzle. In the present tests this condition has been met by the provision of a relatively large nozzle pipe to the underside of which the nozzle box is fastened.

The ratio of the mean actual velocity to the theoretical velocity is taken as the velocity co-efficient (ϕ), and the efficiency of the nozzle (η) is assumed to be the square of the velocity co-efficient:—

$$\text{or } \phi = \frac{c_m}{c} \quad . \quad . \quad . \quad (5)$$

$$\text{and } \eta = \phi^2 \quad . \quad . \quad . \quad (6)$$

TEST MEASUREMENTS.

The readings required to determine the actual velocity of the steam are the measurement of the impulse and of the discharge. The impulse measurement required a considerable amount of adjustment before reliance could be placed on the readings. The lever and cage are nearly, though not completely, balanced by dead weights at one end. This necessitates a zero reading. The steam, when flowing, depresses the lever, and various methods were successively tried to bring it back to an equilibrium position. At first the flanges of the hub at the free end were allowed to rest on the scale pan of an ordinary balance, but trouble was experienced (which disappeared later) owing to vibration of the whole apparatus, and the equilibrium position could not be sustained. Various forms of spring balance were then attached to this hub, but the readings did not reach the required degree of accuracy. When the difficulties of vibration had been overcome by suitable adjustments to the running gear of the apparatus, the following arrangement was then tried and adopted, with one modification.

In this method a scale pan is suspended on knife edges from the end of the lever, where the dead weights are fixed, and calibrated weights are used to record to the nearest twentieth of a pound. The final adjustment is then taken on a calibrated spiral spring, which is attached to the hub at the free end of the lever and which reads to one-hundredth of a pound. After a number of trials with this arrangement, both with steam flowing and with steam shut off, it was found that equal accuracy could be obtained by omitting the spring and using weights in the scale pan to record to the nearest hundredth of a pound. The frictionless gland of the cage pivot, after minor adjustments, works very freely and the whole arrangement is sensitive, when hot, to one-hundredth of a pound thrust. All tests, so far, have been taken at one definite position of the cage relative to the centre of the exit plane of the various nozzles. This distance was determined by the desirability of keeping the lever horizontal. There is then 2½ inches from the exit face of the central nozzle to the top layer of wire netting on the impulse plate. Any tendency to stickiness in the final adjustment is overcome by tapping the lever with a light hammer. While a test is in progress it is the duty of one observer to adjust the stop valve of the steam supply in such a way as to maintain the lever and cage in equilibrium under any chosen thrust.

The measurement of the discharge from the time the tests were commenced has given very little trouble. The condensed steam is run into a tank standing on a weighbridge, which has been calibrated to a quarter of a pound against standard weights. The condensate comes through at an average temperature of 50 deg. C. A drain pipe from the bottom point of the tester collects any steam which may have condensed at low velocities before reaching the condenser, and discharges into the weighing tank. As all tests are taken under superheated conditions on both sides of the nozzle, this amount is very small. The condensate is deflected by hand into the weighing tank at the commencement of a test and turned to waste at the end. This involves a personal error which may vary from the equivalent of no pounds at very low velocities to ½ lb. at very high velocities. Such errors are, of course, spread over the time allowed for each test run.

The Value of Gravity.—According to Helmert's formula, quoted in Kaye and Laby's "Physical and Chemical Constants" (1911 edition), page 11, the value of gravity for the latitude and height of the Dickinson Street Power Station in Manchester, where the tests were carried out, is 32·197 ft. per second per second. As the impulse and discharge measurements are only accurate to four figures, the value of 32·20 ft. per second per second was taken in the calculations of the two velocities.

Pressure Readings.—The initial pressure was taken at a point on the top flange of the nozzle pipe as near as possible to the position of the end of the platinum thermometer. This point is 15 ins. below the entrance for the supply steam and the pipe is 7½ ins. in diameter. With a throat area of 1¼ square ins. in the nozzle, the steam is moving past this point with an average velocity of about 52 ft. per second when the discharge is at its critical value. No reliance was placed in any form of pressure gauge other than the mercury or water column in a U-tube. The pressure readings on the mercury gauge were measured to 0·01 lb. per square inch.

The exhaust pressure was taken from the top of the discharge box where the steam was sensibly at rest. This pressure was at first measured against a second mercury column, but subsequently a water gauge was substituted for greater accuracy.

The atmospheric pressure was recorded alongside the tester throughout the tests from a compensated aneroid which read in inches of mercury to five significant figures and which was set each day against the standard Fortin barometer in the College of Technology.

The initial steam temperature was measured at approximately the same point as the initial pressure, by means of a platinum resistance thermometer supplied by the Cambridge and Paul Scientific Instrument Company, Limited, and calibrated on site. The Wheatstone Bridge of this thermometer was capable of reading to 0·01 deg. C., and the temperatures were recorded accurately to the nearest tenth of a degree centigrade. For very low pressures the reading was taken to 0·01 deg. C. This method of measuring the initial steam temperatures was suggested by Professor H. L. Callendar and was found to be very suitable.

PRELIMINARY TESTS.

Some fifty tests were taken on Parsons nozzles in the main apparatus while the adjustments and refinements, outlined above, were being made. To vary the pressure ratio, two methods were tried: a constant initial pressure with varying back pressure, which is the method of a number of previous investigators, and a constant exhaust pressure at or near atmospheric pressure with varying initial pressures and superheat. The latter method was used throughout the trials described in this report.

A review of these fifty preliminary tests showed that there was a disturbing factor still affecting the results. The nozzles of both impulse and Parsons type were then reset on the nozzle pipes, so as to leave no obstruction below the last nozzle beyond the thickness of the nozzle plate. In order to ensure comparative results between the two types, both pipes were placed side by side on a surface plate and adjusted so that the centre of each group of the three nozzles was the same distance away from the surface of the pressure plate when placed in the tester.

EFFICIENCY TEST RESULTS.

The nozzles for which the tests have been completed for presentation in this report are the thin plate, 20 deg. nominal angle, impulse nozzle and the Parsons standard 480 B nozzles.

Impulse Nozzles.—A cross-section through this impulse nozzle may be seen in Fig. 6, page 379 *ante*, of the First Report. It will be noted that the partition plates have been made very thin (0·04 in.), and that the length of the parallel portion of the throat is made extremely long compared with the throat opening, the ratio being 3 to 1. A record of the salient features and calculations of the tests carried out on this form of nozzle is given in Table I.* The values deduced for the velocity coefficient are plotted in curve 1 of Fig. 1 opposite, against the calculated theoretical velocity. The parallel portion of the throat was then reduced ¼ in. along the nozzle axis to give a ratio of parallel throat to opening of 2 to 1. Table II gives the corresponding test results which are shown plotted on curve 2 of Fig. 1. A third series of tests were then taken with a throat ratio of 1 to 1, Table III, and a fourth set with no parallel throat at all, Table IV. These results are shown plotted in curves 3 and 4 of Fig. 1.

It will be noticed from the values of the exit temperature that in practically every case sufficient superheat was present in the initial condition of the steam to ensure a theoretical superheat condition at the exhaust side of the nozzle. This was an essential feature of all accepted tests, as thereby no doubt could be entertained that the measurement of the force which involved the weight of the cage was a true one (to 1/100th of a lb.), and did not include moisture condensed from wet steam on to the cage. At low pressures a rough check was kept on this condition by allowing steam to blow through a small orifice in the main tester, immediately before or after a trial run, and noting that condensation did not take place until the steam jet had got well into the room.

For most of the tests three nozzles were open, the fourth one, that farthest away from the plate, being blocked up. A few tests at the highest velocities were carried out with only two nozzles functioning. These are marked on curve 1, with a figure 2, and it will be noticed that, within the errors of the experiment, they coincide with check points taken with three nozzles open, care being taken to make the tests comparative. The use of a surface plate in setting the nozzle has been mentioned. The distance from the centre of the exit plane of the central nozzle to the top layer of wire netting on the pressure plate was kept constant. When a trial was in progress the same equilibrium position of the cage was always used and the actual distance referred to above was 2½ in. In this particular nozzle there was one unavoidable variation. It was found, as the partition plates were cut away, that the area across the "parallel"

* Abstract of a report presented to the Institution of Mechanical Engineers on Friday, March 16, 1923.

† Callendar's "Properties of Steam," 1920 Edition, page 59, Equation 24.

* [These tables are omitted from our abstract of the report on account of lack of space.—ED. E.]

portion tended to increase. With a 3 to 1 throat the total cross-sectional area of three nozzles at the mouth was 1·446 sq. in. This gradually increased till it reached 1·6045 sq. in., with a ratio of 0 to 1, showing that the "parallel" portion was in reality slightly convergent. A record was kept of each case as it occurred and the values are given in the Tables referred to.

Probable Accuracy of the Results.

The tables of results and the curves in Fig. 1 record all the tests which were taken to the satisfaction of the experimenters. No point has been omitted unless there was some definite reason to doubt its reliability. On the other hand, no point has been included, even if it fell on or near the curve, if the test showed that all due precautions had not been taken. As an example of the former, it happened that in one set of tests the drainage from the nozzle tester was not included in the weight of the discharge. This omission, though small in quantity, was sufficient to make itself felt at very low velocities, and all the tests in that series were rejected and repeated. As an example of the latter, there was some doubt, on one occasion, as to whether a search tube inside the nozzle tester was not fouling the cage and so affecting the measurement of the impulse. Though more than half the tests carried out in this series agreed very fairly with the final result, the whole series was repeated and the former values rejected. Evidence of experimental consistency is given in curve 1, Fig. 1, where a whole series of check points, marked with the letter C, represents a second set of tests which were carried out after the nozzle pipe had been withdrawn and replaced. In the other curves a check was kept by repeating single points on different days.

An estimate of the maximum possible deviations due to errors of measurement can be made by considering the degree of accuracy of each reading separately, and then comparing the two extreme cases where all these margins are working either for a minimum or for a maximum. The probable error of points on the mean curve due to this cause would be much less than these values, and no individual test should be outside them. An application of this method to Test 40 will give these values for medium velocities. Two further points from the same curve, Test Nos. 38 and 47 in Table I, indicate how the margin varies at very low and very high velocities. In Test 40 the actual velocity is effected directly as the impulse and inversely as the discharge.

The impulse is readable to $\frac{1}{100}$ lb. and may be considered steady during test to $\frac{1}{10}$ lb. Hence the possible variation of F may be $11·69 \pm 0·02 = 11·67$ to $11·71$ lb.

The discharge, allowing for possible errors in timing and reading, is measurable to $\frac{1}{2}$ lb. in 10 minutes. This is equivalent to 0·0008 lb. or say 0·0010 lb. per second. Hence m may vary $0·3504 \pm 0·0010$, or between 0·3494 and 0·3514 lb. Therefore the extreme variation in the calculation of the actual velocity :—

$$c_m = \frac{11·67 \times 32·20}{0·3514} \text{ to } \frac{11·71 \times 32·20}{0·3494}$$

$$= 1{,}069 \text{ to } 1{,}079 \text{ ft. per second.}$$

$$= \pm 0·5 \text{ per cent.}$$

The theoretical velocity involves measurements of T_1, P_1, P_2 and the barometer.

The temperature (T_1) is measurable to $\pm 0·1$ deg. C. with the refined apparatus in use. Hence $T_1 = 460·4 \pm 0·1 = 460·3$ to $460·5$ deg. C. The initial pressure (P_1) is measurable on the mercury gauge to 0·01 lb. per square inch abs. The difficulty of the reading, however, makes it possible, though not probable, that the error may be as much as $\pm 0·03$ lb. per square inch abs. In such a case :

$$P_1 = 19·43 \pm 0·03 \text{ lb.}$$
$$= 19·40 \text{ to } 19·46 \text{ lb. per square inch abs.}$$

As the barometer is readable to five significant figures, the error in P_2 is within the accuracy of the calculations and may be neglected.

Hence $P_2 = 14·36$ lb. per square inch abs. If now the theoretical velocity is calculated as for two separate tests, it will be found to vary between 1,148 ft. and 1,153 ft. per second, or $\pm 0·25$ per cent. Hence the velocity coefficient may vary in the extreme between :—

$$\frac{1068}{1153} \text{ and } \frac{1079}{1148} = 0·9272 \text{ and } 0·9401 \text{ or } \pm 0·75 \text{ per cent.}$$

Test 38.—For low velocities the same method may be applied, providing errors of measurement are adjusted to suit the altered test conditions. The discharge, for instance, is taken over 30 minutes instead of 10 minutes giving a correction of $\pm 0·0005$ lb. per second. The initial pressure is measured on a water gauge, and the accuracy may be taken at $\pm 0·005$ lb. per square inch. The impulse also can be adjusted to vary not more than $\pm \frac{1}{250}$ lb. By an application of the same analysis the velocity coefficient may vary between :—

$$\frac{352·6}{368·0} \text{ and } \frac{359·1}{365·0} \text{ or } 0·9840 \text{ and } 0·9581 = \pm 1·35 \text{ per cent.}$$

Test 47.—For very high velocities the impulse is measurable to $\pm \frac{1}{250}$ lb., but the discharge only to $\pm 0·002$ lb. per second. The temperatures and pressure variations are as accurate as in Test 40. This gives values for the velocity coefficient of :—

$$\frac{2000}{2139} \text{ and } \frac{2017}{2133} \text{ or } 0·9350 \text{ to } 0·9441 = \pm 0·54 \text{ per cent.}$$

These variations—

$\pm 1·35$ per cent. for very low velocities,
$\pm 0·75$ per cent. for medium velocities,
$\pm 0·54$ per cent. for very high velocities,

are an indication of the possible errors of observation and represent the effect when all possible errors of reading are cumulative. The accuracy of the mean curve itself is considerably greater than these extreme variations, as far as errors in measurement are concerned. An application of Peter's and Bessel's formulæ for the probable error of the mean, to clusters of points reduced by the slope of the curve to velocities of 380 ft., 1,150 ft., and 1,830 ft. per second respectively, gives the following average of the variation of the curve itself.

$\pm 0·335$ per cent. for low velocities.
$\pm 0·120$ per cent. for medium velocities.
$\pm 0·086$ per cent. for high velocities.

There remains to be considered the actual fluctuations of the general steam conditions during a test run, and the possible variations in the superheat from day to day. The consideration of these is largely a matter of judgment as to when and how any particular test is taken. Control can be obtained to a considerable extent, by arranging for a suitable number of check observations to be taken on different days. If due allowance is made for such fluctuations it would seem that the values given by the curves shown in Fig. 1, may be taken as accurate to :—

$\pm 1·0$ per cent. at low velocities.
$\pm 0·5$ per cent at medium velocities.
and $\pm 0·4$ per cent. at high velocities.

This range is indicated on the curves in Fig. 1 by shading, and it will be noted that all experimental points fall within these limits.

Reaction Nozzles.

The efficiency tests of reaction nozzles were carried out on Parsons standard 480 B. blading, which was clamped with its own distance pieces into a nozzle-box as shown in Fig. 2. This drawing shows five openings, but in the tester the two nozzles farthest away from the cage plate were blocked up and the tests carried out with three nozzles functioning. The centre of the exit plane of the middle nozzle was made to coincide with that of the impulse setting, and the distance from this point to the first layers of netting on the plate was kept the same in both cases, this distance being $2\frac{1}{2}$ in. in the present tests. Care was also taken to see that the steam passage behind the nozzles was similar in shape and in general proportions. The results of tests taken on this reaction nozzle are given in Table V. The curve, marked No. 5, derived from these tests can be seen plotted in Fig. 3.

A previous set of some 33 tests, extending over six weeks, had been carried out on the same nozzles, with a different setting, before the impulse tests. The results of these previous tests are shown by dots on the same diagram, and a chain-dotted curve drawn through them which is marked No. 5a. This curve is valuable, in that it corroborates the general shape of the standard Parsons curve No. 5, and also justifies its extension to velocities of the order of 1,850 ft. per second. It was found, however, after the impulse nozzles had been tested, that the first Parsons curve could not be used for comparative purposes, as the settings differed in two respects. In the first Parsons setting there was a pocket $\frac{3}{4}$ in. square in the toe of the steam chamber below the inlet to the last nozzle, which did not exist in the impulse nozzles. Again, on the exit plane of the impulse nozzles, there was no side obstruction or projection, the plates

Fig. 1. IMPULSE NOZZLE. 20° NOMINAL ANGLE. PLATES 0·04" THICK.

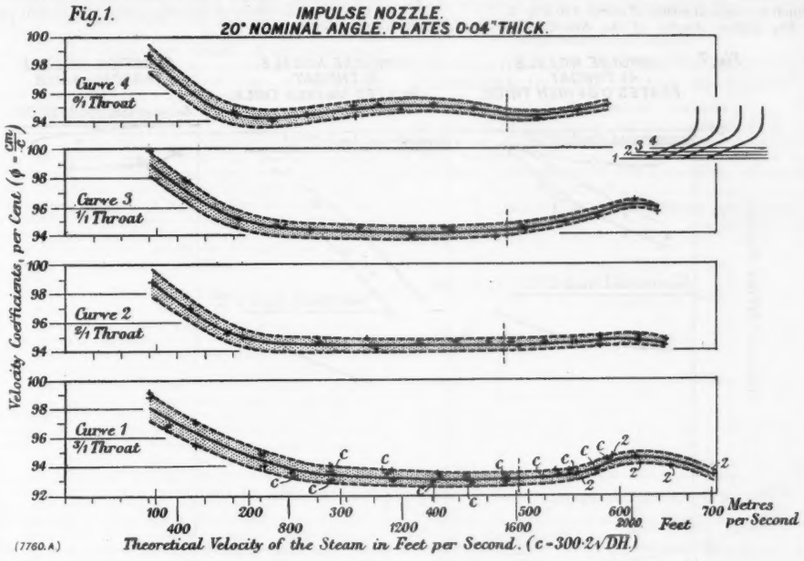


Fig. 2. REACTION NOZZLE-BOX. PARSONS 480 B BLADES.

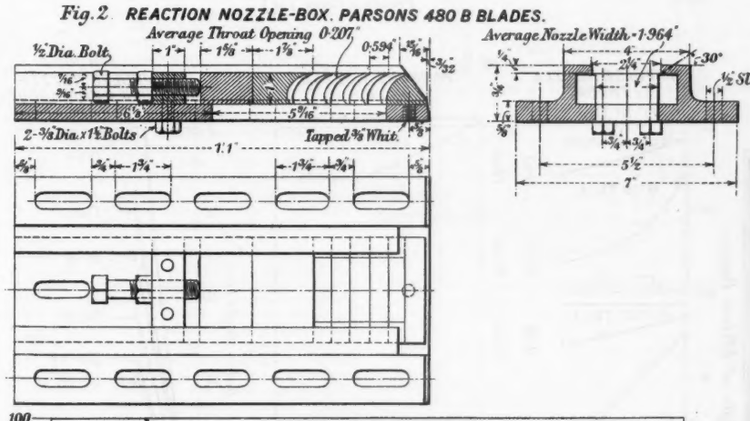
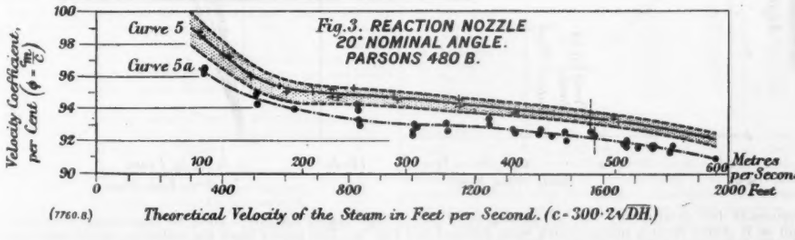
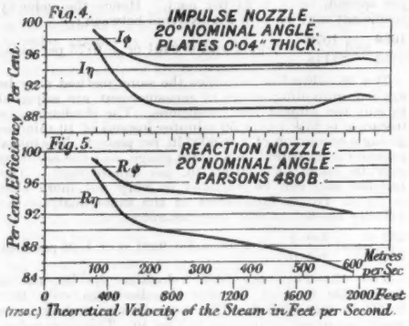


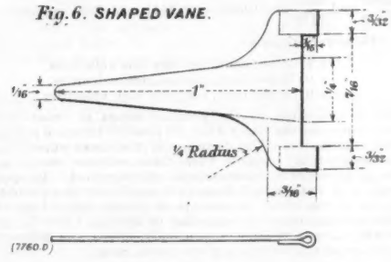
Fig. 3. REACTION NOZZLE 20° NOMINAL ANGLE. PARSONS 480 B.



and their side supports being planed off flush. The Parsons blade setting, as can be seen from the end elevation in Fig. 2, had two parallel clamping edges, ¼ in. deep, on each side of the partitions, which may or may not have obstructed the free flow of the steam after it had left the nozzle. It was not possible, with the present arrangement, to eliminate those edges altogether, but for the standard tests of curve 5, the corners were bevelled off to an angle of 30 deg., as shown by the dotted lines on Fig. 2. The combined result of eliminating these two obstructions to the free passage of the steam was to lift the curve bodily some 1·2 per cent.

The first Parsons curve (No. 5*a*) also contained sufficient check points to enable a similar analysis to be applied with respect to their probable accuracy. The result has been included in Fig. 3, in a similar manner to the impulse curves in Fig. 1.





(*a*) Close Up. (*b*) Set Out ½ In.

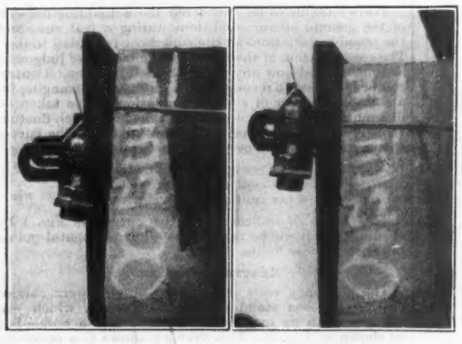


FIG. 8. SHAPED VANE AT EXIT PLANE OF IMPULSE NOZZLE FOR MEASUREMENT OF ANGLE OF EFFLUX OF STEAM.

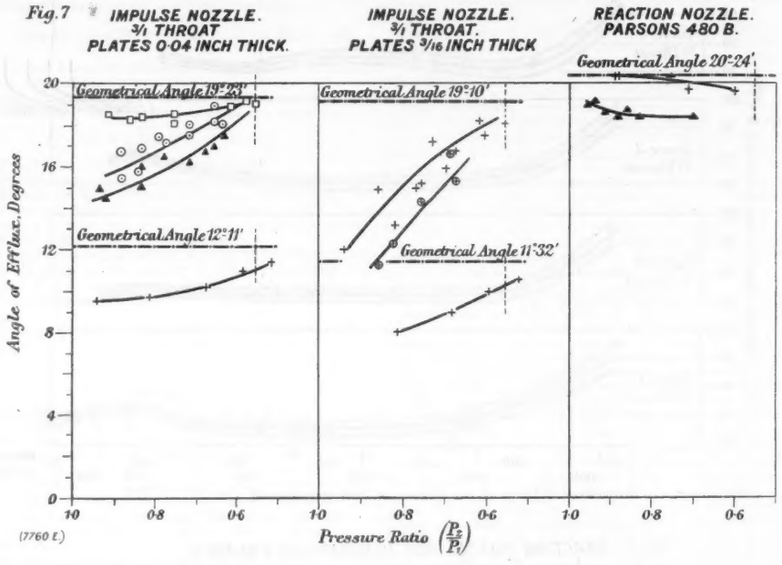
Effect of Initial Superheat on the Value of the Critical Velocity.—Owing to the fact that all tests on both impulse and reaction nozzles were carried out in the superheated region, for reasons already explained, the value for the critical velocity will differ from that of 1,480 ft. per second, which is the figure commonly assigned to dry saturated steam. The actual value for each curve is most readily obtained by plotting the pressure ratios which are given in column 4 of each table, against the theoretical velocities to be found in column 9. For superheated steam the critical velocity occurs at a pressure ratio of 0·546, and the value obtained from such graphs is marked by a short dotted vertical line on each of the curves in Figs. 1 and 3.

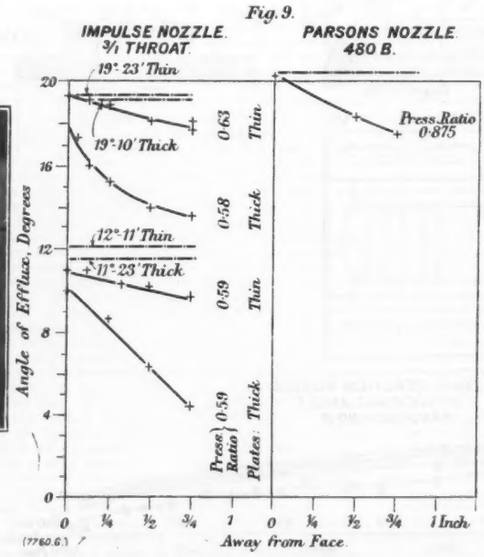
The Efficiency of Convergent Nozzles.—The curves of velocity coefficients of impulse nozzles with thin partition plates and 20 deg. nominal angle, which are shown in Fig. 1, would indicate that there is little to choose between a parallel portion twice the length of the throat opening (curve 2), and no parallel portion at all (curve 4). It would seem, however, from curve 1, that a longer parallel throat than 2/1 tends to affect the efficiency adversely. A reference to the programme of tests in the First Report of this Committee, page 379 *ante*, will show that further evidence on this point is being obtained from tests which are now in progress. For the purpose of deducing a comparative efficiency curve of this particular nozzle, a composite velocity curve has been prepared, which is the mean of curves 2, 3 and 4, in Fig. 1. This curve, marked I_ϕ, is shown in Fig. 4. The efficiency corresponding to the relation $\eta = \phi^2$ is shown on the same diagram by the curve marked I_η. The efficiency of a reaction nozzle when tested as much as possible under similar conditions to this impulse nozzle is shown in Fig. 5, by the curve marked R_η. This curve is deduced in a similar manner from the velocity coefficient (R_ϕ), which is a reproduction of curve 5 in Fig. 3.

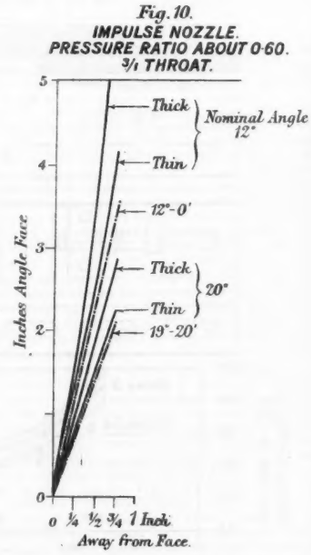
The Efflux Angles of the Steam.—The preliminary experiments for determining the efflux angles of the steam as it issued from a nozzle which were referred to in the First Report of this Committee, brought out some points which were considered worthy of further investigation. The tests were originally devised in order to ensure perpendicular impact of the centre of the steam jet against the impulse plate in the main tester. This entailed a determination of the mean direction of the jet, some time after it had left the nozzle face. The tests have now been extended to cover the whole path of the stream between those points and a point close up to the nozzle face. The method of experiment, which has been for the most part described in the first report, consisted in photographing a fine indicator against a white background as it floated in the steam issuing into the open air.

Indicator cord, which was used in the preliminary tests, did not prove very suitable for prolonged analysis, as it rapidly disintegrated under the action of the steam. For the present series of tests a metal strip about $\frac{3}{16}$ in. wide and 0·015 in. thick was used to act as a vane in the stream. This strip was mounted on a very fine wire 0·009 in. in diameter, which could be stretched across the nozzle opening at any desired point by means of adjustable supports. In many of the later tests this parallel metal strip was replaced by a vane shaped as in Fig. 6, which enabled readings to be taken of angles even closer to the face, since the broader portion at the base would take up the direction of the stream at that point, while the pointed portion was long enough to enable this angle to be measured on a photograph.

The nozzles already tested under these conditions are those laid down in the programme of tests and shown in Figs. 6, 7, 8 and 9 of the First Report, and in Fig. 2 of this report, and Table VI gives particulars of the dimensions of these nozzles. Each measurement is the mean of five or six micrometer readings taken at different parts of the nozzle.







The angles measured from 65 negatives are shown in Fig. 7. The points have the following significance :—

	Thick. In.	Long. In.	
Parallel metal strip, $\frac{3}{16}$ in. wide	0·015	$3\frac{1}{4}$	= ▲
Parallel metal strip, in. $\frac{3}{16}$ wide	0·015	2	= ⊕
Parallel metal strip, $\frac{3}{16}$ in. wide	0·015	$1\frac{1}{4}$	= ⊙
Parallel metal strip, $\frac{3}{16}$ in. wide	0·015	$\frac{3}{4}$	= □
Strip shaped as in Fig. 6, equivalent to...		$\frac{1}{2}$	= +

The method of obtaining these angles consisted in enlarging the negatives in a lantern and measuring the image on the screen direct with a large protractor. The magnification was always sufficient to ensure an accuracy of at least ½ deg. A curve has been drawn through each group of points which indicates the general variation in angle for different pressure ratios to about the critical value. In the case of the 12 deg. impulse nozzles, the longer strips clung to the vertical face of the nozzle

and no results could be obtained. Another method was therefore devised to get some indication of the direction of the jet at or near the point where it would strike the plate when the nozzle was set up in the tester. This method consisted in floating the shaped vane of Fig. 6 at different distances away from the exit plane of the nozzle, and obtaining records of the angles taken up along the path of the jet for a constant pressure ratio. This method can be seen in the two photographs of Fig. 8, the first one showing the vane close up to the exit plane of an impulse nozzle and the second one the same nozzle with the vane set out $\frac{1}{2}$ in. The results of such tests can be seen in Fig. 9. With the help of this diagram a magnified scale chart was prepared of the probable path of the centre line of the steam jet, which showed not only the most suitable angle at which to set any particular nozzle in the main tester, but also, by a combination with the graphs in Fig. 7, the probable variation in this angle for different pressure ratios. A reproduction of such a chart on a small scale for a pressure ratio of about 0·6, is shown in Fig. 10. This chart is for impulse nozzles with 3/1 throats. The effect of thick plates on the angle of efflux is very apparent.

SUMMARY AND CONCLUSION.

The committee believe that the results presented represent the first attempt to carry out on a full-size scale a systematic investigation into the efficiency of steam turbine nozzles. The difficulties encountered have undoubtedly been serious, and have only been surmounted by recognising limitations in the conditions of test. Such limitations should not be lost sight of when the results of this report are discussed. In brief they amounted to :—

(1) *The Use of the Impulse Method for obtaining the Thrust of the Steam at the Exit of the Nozzle.*—This meant that, in the present tests, the central portion of the jet had travelled a distance of 2½ in. from the exit of the nozzle before its thrust was recorded. Careful tests had shown that confidence could be placed in the correctness of this record as compared with the reaction method (to which a similar condition must pertain), but the fact remains that the thrust was not, and could not, be measured at the point where it would act in a steam turbine. However, by keeping the amount of free jet constant throughout, the tests of both impulse and reaction nozzles may be considered strictly comparative, and the shape of each curve may be taken as representative for that particular nozzle type.

(2) *The Use of Superheat on Both Sides of the Nozzle.*—This was found to be necessary in order to ensure that no moisture was present on the impulse plate and cage when the thrust was being measured.

(3) *The Variation in the Initial Superheat.*—This was brought about by the decision to maintain the exhaust pressure at or near atmosphere which made for greater simplicity and therefore accuracy.

(4) *The Use of Commercial Nozzles.*—For both impulse and reaction types, commercial nozzles with their attendant variations in finish were used, and no attempt was made to improve the steam passage or adjust any small discrepancies in dimensions. The only departure from standard was that the nozzles were mounted on a parallel instead of a circular base.

(5) *The Use of Callendar's Steam Tables.*—Although recognised as the most accurate and the only consistent set of steam regulations, these tables are not the only ones used throughout the world. The numerical values and even the shape of the efficiency curves could vary if other tables were used.

(6) *The Calculation of the Heat Drop.*—For the purpose of determining the theoretical velocity this involved the accurate determination of the difference between the two large quantities. This was one of the limitations which prevented the efficiency curves from being extended to lower velocities than 300 ft. per second in the present tests, and rendered the lower portion of the curve more inaccurate than the higher regions. The efficiency curves obtained under such conditions as these may therefore be taken to represent, relatively, the behaviour of such impulse and reaction nozzles between theoretical steam velocities of 300 ft. per second and 1,980 ft. per second, and, absolutely, the general shape of the curve between these steam speeds. Owing to the fact that the impulse was not measured close up to the nozzle face, the actual numerical values for efficiencies in a turbine are not likely to be less than the values obtained, and may be slightly higher.

For the particular nozzles tested the efficiencies of a Parsons nozzle over the working range of modern reaction turbines may be taken as follows :—

98·0 per cent. at 280 ft. per second.
92·1 per cent. at 500 ft. per second.
90·2 per cent. at 700 ft. per second.

For the working range of the impulse nozzle, say, between 980 ft. per second and 1,300 ft. per second, the efficiency is constant at 89·1 per cent. The experience of the tests brought out very clearly the importance of having no obstruction for the passage of the steam on either the inlet or the exit side of the nozzle if the best and most reliable results are to be obtained. On the exit side this reservation applied not only to any interference in the free flow of the jet after it left the tips of the nozzle partition, but also to flat surfaces in and below the exit plane. A complete series of tests were rendered abortive because some 2 in. of flat surface was left below the last nozzle of the first Parsons nozzles.

The angle of efflux of both Parsons and thin plate 20 deg. impulse nozzles appears to be practically the geometrical angle of the nozzle close up to the face, but thick partition plates undoubtedly affect this angle to the extent of at least 2 degs. at or near the critical velocity, and very much more at larger pressure ratios. The fact that in all the efflux tests an inward curvature of the centre of the jet was found as the steam got further away from the point of exit, shows that the pressure is not constant across the face of the exit plane, but must be higher on the side which first leaves the partition.

The committee have again to acknowledge their indebtedness to the Department of Scientific and Industrial Research and to the British Electrical and Allied Manufacturers' Association for continuing their contributions towards the cost of the research, and would also like to record their satisfaction of the work done by the research assistants Messrs. J. E. Shakeshaft, L. J. Cheshire, and T. H. Jones. In conclusion, the committee would again point out that further tests are in progress, and that they would welcome a discussion of the results they have already obtained, with a view to assisting them in their further investigations.

REMARKS ON SOME OF THE PRESENT-DAY PROBLEMS IN THE DESIGN OF SHIPS.*

By A. C. F. HENDERSON, Associate.

IN presenting this paper my principal object is to refer to some of the problems of ship design from a point of view somewhat different from that usually held by contributors to the annals of this Institution. It occurs to me that it is possible for Naval Architects to concentrate on theoretical and technical problems at the risk of not making sufficient effort to anticipate the subsequent difficulties that arise in connection with the actual operation of the ship in being. Admittedly the running of ships is the owner's concern, but if the designer was more closely acquainted with the owner's difficulties, and the owner had a fuller appreciation of the problems of design, it is felt that greater efficiency would result.

There are many problems which we could investigate brought about by the reasons which I have already quoted, and perhaps I may be allowed to touch on a few of them, not necessarily in order of precedence, in the hope that they may be of interest and provoke discussion that will be beneficial to owners and designers of British ships in general. In introducing them it may be remarked, not necessarily as an excuse, that the economic position of Great Britain as a mercantile nation has never before been so seriously threatened, and it is my opinion that it is not only desirable but absolutely necessary that there should be the fullest possible interchange of opinion on every question, however small, involved in the evolution of the design of efficient ships of all types.

* Abstract of a paper read at the Spring Meetings of the Institution of Naval Architects, March 21, 1923.

Dimensions.—In the first place if we review the dimensions of the largest ships of the past thirty-five years it will be seen that there has been a steadily growing increase in size, especially in ships engaged in the North Atlantic passenger trade.

The diagram, Fig. 1, shows the gradual increase in length and breadth, and suggests that had it not been for the war, it is probable that there would have been engaged in the North Atlantic trade a ship of 1,000 ft. in length. At present the longest ship is the Majestic, which was launched prior to the outbreak of war in 1914. This vessel is about 950 ft. overall.

There is probably, from many considerations, a limit of size which cannot be exceeded, but there is little doubt that before many years have passed a ship 1,000 ft. long will be built. One of the very first considerations in design before making any increase in dimensions from existing practice is the availability of graving dock facilities. The history in this respect shows that it is usual for increase in dimensions to be adopted before the dock authorities have provided the necessary accommodation. This is not always so, as the Mersey Docks and Harbour Board constructed the Gladstone Dock, Liverpool, in order to provide for vessels of the Aquitania size, and in doing so anticipated a considerable increase in the dimensions of future vessels. There is no doubt that harbour authorities both in this country and in the United States have recently made special efforts to meet the demands of increasing dimensions. The trend of high-class passenger traffic has necessitated the transfer of the big ships from Liverpool to Southampton, and this, unfortunately, has practically excluded the Gladstone Dock for dry docking, owing to the cost of moving these large ships. The only alternatives are the existing dock and new floating dock at Southampton, and the dock in Boston, U.S.A., whilst I believe a dock of the necessary dimensions is projected for Havre.

Fig. 1 DIAGRAM SHEWING INCREASE IN LENGTH, BREADTH & DRAUGHT OF LARGEST STEAMSHIP

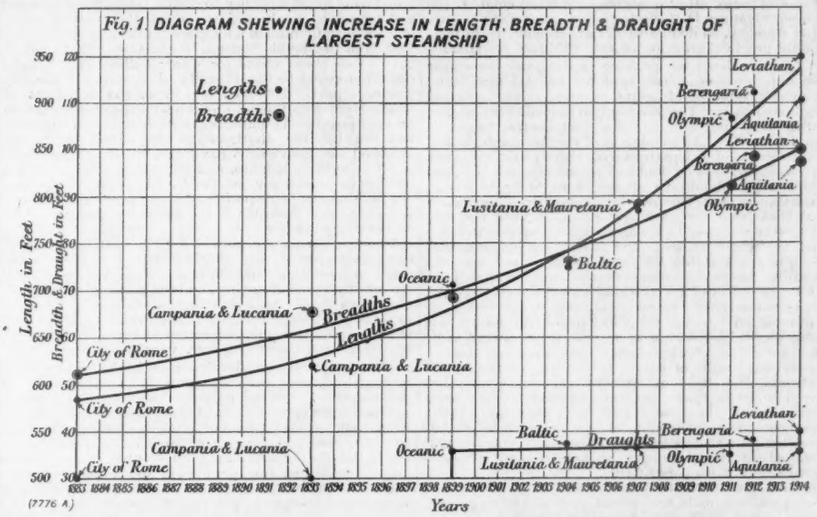
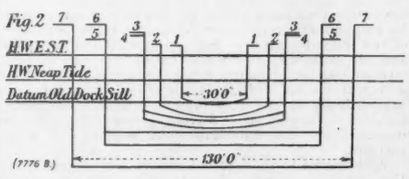


Fig. 2



	Date.	Width.	Depth Below Old Dock Sill.
		ft.	ft. in.
1. Old Dock	1713	30	O.D.S.
2. King's Dock (East)	1788	50	6 0
3. Princes Half-Tide Dock ..	1868	65	9 7
4. Langton Dock	1879	65	12 0
5. Canada Dock (Deepened) ..	1895	100	14 0
6. Sandon Half-Tide Dock ..	1901	100	20 0
7. Gladstone Dock	1913	130	30 0

One of the greatest needs, therefore, of the future will be graving dock accommodation for very large vessels in New York and some other adjacent port, for it is not unreasonable to suppose that international rivalry will cause the dimensions of ships built to replace those which now are operating on the North Atlantic service to increase, and it must be remembered that the tendency is for all the big ships to be laid up at approximately the same time during the slack season. Briefly, it should be realised by all authorities contemplating any scheme of graving docks, piers, sheds, &c., devised either for the improvement of, or as an addition to, existing facilities on the North Atlantic route, that they should be guided by the assumption that as soon as the world returns to economic stability ships over 1,000 ft. in length will be built.

The diagram, Fig. 2, shows the growth in size of entrances to dry docks in Liverpool which, while it only applies to one port, tends to show the general development in all ports. This diagram, if taken in conjunction with the curves showing length and breadth, illustrates the development of ships *versus* docks. As regards the draught of these large ships it will be noticed in Fig. 1 that for a period of years the maximum draught remained constant, although length and breadth continued to increase. This, perhaps, is natural, as the steps which have to be taken by harbour and dock authorities to increase the available draught of water are far more serious than those required to meet any increase in length or breadth. The time is now coming when it will be necessary for the river entrances both to New York and Southampton to be deepened. Ships already in existence have sailed drawing 40 ft. of water, but only under favourable conditions. The requirement of the future will be ability to sail with that draught under practically everyday conditions, since increased draught makes for economy.

Stability.—The question of stability is, perhaps, a dangerous subject for me to approach, but so far as I can discover at the present time there is no source of information from which the shipowner or designer may derive knowledge of what is considered to be a correct amount of initial stability for vessels of the following types :

(1) Fast passenger ships which sail with practically a fixed cycle of loading between two terminal ports; (2) vessels of the intermediate type which carry but little cargo in one direction and practically capacity cargoes in the other; (3) cargo ships which may call at a large number of ports collecting cargo of different densities at each one. It is not intended to deal theoretically with this subject, the object being rather to examine the question from the practical point of view.

In evolving the design of any ocean-going steamer it is customary to aim at obtaining a certain measure of initial stability in conjunction with a sufficient range of stability, and the whole difficulty nowadays in determining the necessary degree of initial stability has been greatly aggravated through various causes which have arisen in the last few years. With sufficient data to draw from, it is possible to build a ship to have, within limits, a certain measure of stability. It is, in fact, a problem depending largely upon calculation and inference drawn judiciously from actual experience, namely, from the behaviour of existing ships on which comparison can be made between calculation and actual data derived from inclining experiments. The real crux of the matter is the fact that our definite knowledge of the stability qualities of any ship is confined in ordinary practice to data obtained from an inclining experiment. At that point our definite knowledge ends, and although periods of roll and many other qualities may be calculated, the knowledge gained is theoretical and comparative only. Initial stability, as deduced from experiment, is, in fact, the only practical criterion of seaworthiness available.

It has long been the practice in designing passenger vessels of the intermediate type for the Atlantic trade, to aim at a condition of neutral stability in the equipped or light condition. This has resulted in loaded conditions, varying according to type, of a metacentric height of from 2 ft. to 3 ft. In the design of the Aquitania, which was somewhat of a departure with regard to dimensions, there was considerable doubt as to the amount of initial stability that should be aimed at in order to ensure seaworthiness and comfort for passengers, bearing in mind that from the passenger point of view the ship which is too stiff may be a worse proposition than the ship which is slightly tender. The general opinion was that the dynamic stability for any angle of roll was the governing factor for seaworthiness and comfort in a seaway, the effect of initial stability, was theoretical only, and, therefore, could be made as small as possible so as to provide an "easy" roll. On paper, no doubt, this theory was defensible, but in practice it has proved to be fallacious. As actually built, the Aquitania had a metacentric height of about 4 ft. 6 in. in the loaded condition, and from subsequent experience this has proved to be adequate but not excessive. In all these calculations it must be remembered that large liners grow materially in weight, either temporarily or permanently, to a remarkable extent, most of which weight is added in the passenger accommodation, which is principally in the superstructure.

In the North Atlantic trade, where large numbers of passengers and mails are carried, and where cargo only forms a very small part of the total deadweight, it is essential to provide larger metacentric height than would appear necessary, for the following reasons: The ships on leaving the port of departure have large quantities of baggage and mails piled up on the weather decks; these are stowed away in the holds as the vessel is proceeding down Channel. This condition is probably of no importance, as the ship, with a complement of fuel, fresh and feed water, stores, &c., is probably in her most stable condition; but before the vessel reaches her destination, it is necessary as a preliminary to expeditious disembarkation to carry out in reverse order the same operation. By this time a very large proportion of the fuel, stores, and water has been consumed and stability considerably reduced, and the operation, therefore, assumes quite a different aspect from a stability point of view. The opportunity for taking in water ballast to counteract this is limited if excessive trim by the stern is to be avoided, as all high-speed Atlantic ships tend to trim considerably by the stern, due to the disposition and weight of the machinery; and in order to keep the ship on an even keel before entering port, no ballast, as a general rule, can be put in abaft about three-eights of the length from the stem. In consequence, there is a weakened resistance to heeling through side wind pressure, which is always a serious consideration in these days of lofty and extensive superstructures, and at the same time there is the tendency of passengers to congregate on one side of the uppermost decks when nearing port. It, therefore, follows that the worst possible combination of all these contingencies ought to be provided for, and met by providing for a substantial measure of metacentric height, so that the comfort and confidence of passengers is assured. This condition of affairs hardly comes under the province of the shipbuilder who is not engaged in the actual operation of ships, but nevertheless it is often left in his hands.

It is a well-known fact that orders placed for ships to carry a specified deadweight sometimes produce unexpected results. One ship may be able to carry its deadweight, but part of it will have to be of water or some other form of ballast; another may have insufficient capacity to carry full deadweight in the form of ordinary cargo. Deadweight is generally considered as an indication of value in the buying and selling of cargo ships, and I venture to say that a closer study of this question in the early stages whould bring its own reward.

Again, one of the chief sources of anxiety on board ship as regards stability is the necessity, especially in oil-burning ships, of having free surfaces in the double bottom tanks. In service the minimum number of tanks which must have a free surface varies in different types of ships, but generally includes one tank from which make-up feed for boilers is being drawn, one tank for domestic water, one in use as a return tank from the ship's water service system, and one or two tanks in cases where oil fuel is carried in the double bottom. The free surface in these tanks produces a permanent reduction in the metacentric height of the vessel in service, and a further loss is temporarily incurred while manipulating ballast tanks. This problem has taken on an entirely new aspect in the last few years largely owing to the introduction of oil fuel. Previously the liquid carried, namely water, although large in amount could be pressed up in such tanks as were not actually being drawn from. To do this with oil fuel is impracticable if spilling of oil over the side is to be avoided, which state of affairs is in itself objectionable, and results in the payment of a heavy fine if it occurs in port. Under present-day conditions inclining-experiment stability may have very little bearing on conditions which arise when actually at sea. No doubt, however, much could be and is being done to reduce free surface effects by introducing more longitudinal subdivision into double bottoms.

The question of stability in the case of intermediate vessels which are loaded down on only one-half of a round voyage and of deciding upon the most satisfactory design for such vessels provides a very difficult problem. The majority of the freight carried being in one direction only, it is a *sine qua non* that large capacity be provided. This, however, calls for a full-lined ship and makes it a matter of great difficulty to obtain satisfactory draught and trim with small cargoes. From the capacity point of view the minimum of hold space is taken up by carrying fuel oil in the double bottom, but this practice discounts the use of these tanks for water ballast in the light condition owing to the difficulty of disposing of the oily water in port. There is, of course, the expedient of fitting large deep tanks to obtain sufficient immersion to prevent possible slamming when running into a head sea, but this has the disadvantage that these spaces are rendered less convenient for cargo, having of necessity small watertight hatches, and the stowage being broken up by the necessary steelwork. A really cheap and effective means of disposing of oily water in harbour is not only very desirable but a necessity under modern oil-burning conditions.

In ships designed primarily for the carriage of cargo the adjustment of metacentric height is largely in the hands of the captain and officers. In cases where designs are repeated time after time, and the resultant ships trade on known routes on which the nature and quantity of cargo is well established, individual initiative on the part of the ship-master is not necessary to any marked extent. Such conditions are, however, very exceptional.

Machinery.—Recent developments in the various types of propelling machinery have provided a wide choice for the designer, but up to the present the experience gained in the newer types has provided no sure guide as to what is the best for any particular set of conditions. We have passed through the stages of single, compound, triple and quadruple expansion reciprocating engines, we have had direct-acting, single-reduction and double-reduction turbines, and are now in the throes of internal-combustion reciprocating engines and electric propulsion. Geared turbines have given trouble with their teeth. While the ordinary steam-driven reciprocating engine is suitable for low and moderate powers, it is unsuitable on account of the space occupied in high-powered Atlantic vessels, and the same may be said so far of the internal-combustion engine, although I believe great progress can and will be made in this direction. The only two alternatives, therefore, at present available are geared turbines and electric drive deriving power from generators operated by internal-combustion engines or steam turbines.

With regard to the internal-combustion engines, while they may be economical, constructional difficulties have yet to be overcome before they can be used in marine work where very large power is required, as the number of units and the necessary subdivision of the hull makes the question of control for manœuvring very difficult. The internal-combustion electric combination offers many advantages in economy of fuel, but here again a limit in power is soon reached in revolutions and size of the generators. An installation might be satisfactory on a fixed bedplate, but it offers many practical difficulties when put into a ship.

If electric drive is desired, the most reliable method of producing power in a ship available at present appears to be turbo-generators. This of course makes it necessary to have in train, boilers, turbines, generators, motors—which in the aggregate does not suggest any great economy of space or weight and certainly not in initial cost, and probably not in crew; apart from any tonnage effect there is no very great advantage in compressing the machinery spaces.

There is another aspect of the question of choice of machinery which is of primary importance, and that is the difference in weight of various installations of the same power. It was somewhat of a surprise to some designers to find that the centre of gravity of machinery rose with a change from triple-expansion reciprocating machinery to single-reduction turbines. Another important consideration is the tendency towards reduction in machinery weights. It is only natural that in the ordinary course of engineering progress the weight of machinery and fuel per horse-power-hour should be reduced. With oil fuel and internal-combustion engines the change is very marked, and if the fuel is stowed above the double bottom not only is the weight reduced but the centre of gravity is raised considerably. This, taken in conjunction with the demand for elaborate accommodation high up in the ship, forces an increase in beam and consequently in cost, in order that the necessary stability may be provided.

In high-powered vessels of large size any great economy in weight of fuel makes it increasingly difficult to maintain satisfactory trim and stability in all sailing conditions. Again, when good form is essential in order to attain high speeds, the shift of centres of buoyancy and flotation between light service condition and full load sailing condition renders it necessary to make provision for large trimming facilities, whilst when it is necessary, as is often the case, to get the lightest possible even keel for entering graving docks the position is even more difficult. The sinkage caused by the necessary weight to avoid trim by the stern is such that any reduction in draught tends to be neutralised.

CATALOGUES.

Motors and Dynamos.—A quite extensive list with prices and full particulars of small motors and dynamos has come to hand from Messrs. Todman, Ryall and Co., Limited, 38, Grosvenor Gardens, London, S.W. 1.

Oil Separation.—The advantage of separating the oil from exhaust steam is well recognised from the point of view of boiler efficiency, and it is of equal importance where the exhaust from reciprocating engines is utilised in low pressure turbines, or for various industrial heating processes. The catalogue of separators recently issued by Messrs. Bakers (Leeds), Limited, Hunslet, Leeds, is well worth the attention of persons interested in this subject.

Clutches.—Centrifugal clutches made to allow electric motors to run up, to say three-quarters, of their full speed before taking the load and then to take it gradually and easily, are dealt with in a catalogue which has come to hand from Messrs. Thomas Broadbent and Sons, Limited, Huddersfield. The clutches may be used with advantage even with very small motors, and the catalogue includes particulars of a simple design of pulley and clutch for powers from ½ h.p. upwards.

Laboratory Apparatus.—A copy of the seventh edition of their catalogue of general chemical and laboratory apparatus and supplies has reached us from Messrs. A. Gallenkamp and Co., Limited, 19, Sun-street, Finsbury-square, London, E.C. Extending to over 550 pages and strongly bound and conveniently indexed, the catalogue includes particulars of a very full range of instruments, tools, vessels, &c., as well as of various articles and materials used in laboratory work.

Draught Gauges.—Two instruments for indicating light pressures or vacua are described in a circular catalogue received from Messrs. J. Hopkinson and Co., Limited, Huddersfield. One of the instruments indicates on a single dial the draught in a boiler flue, while the other has three dials indicating the pressures at the flue, grate and fan. These instruments are of all-metal construction, well guarded, easily read and capable of being checked and adjusted in comparison with a standard U-tube water gauge.

Extraction Pump for Condensers.—A centrifugal pump for extracting water from surface condensers under high vacua is described in a special catalogue received from the Mirlees Watson Company, Limited, Scotland-street, Glasgow (London: 7, Grosvenor Gardens, S.W. 1). Air leakage into the system through the pump glands is prevented by the method of construction, which is such that there is a positive pressure of water on the glands; there is thus a tendency for water to escape outwards rather than for air to leak inwards.

Oil Engines.—A catalogue of their vertical oil engines made in 12 sizes ranging from 30 h.p. to 300 h.p. has been received from Messrs. Marshall, Sons and Co., Limited, Gainsborough. The various powers are obtained from one or more cylinders of which there are four standard bores, and all parts are made to interchangeable gauges, so that any damaged or worn parts may be replaced. The single cylinder engines are fitted with two flywheels when very steady running is required, as is the case with engines driving generators for electric lighting.

Steam Turbines.—The steam turbine for small powers generally and for auxiliary service to large power units has been specially studied by the Terry Steam Turbine Company, Hartford, Conn., U.S.A., whose latest catalogue recently to hand, gives an interesting description of the construction of their turbines and an account of the many purposes to which they have been successfully applied. Mention is made of the fact that eight of these turbines, each of 300 h.p., were installed in a New York power-house in 1907 for driving centrifugal boiler feed pumps, and are still in service.

Electric Mine Lamps.—A series of electric safety lamps for use in mines, including miners' hand-lamps, bull's-eye lamps for officials, small pocket emergency lamps, shaft and roadway lamps, and cap lamps, is to hand from the Thor Electric Safety Lamp Company, Limited, Rea-street South, Birmingham. The cap lamp is fixed to the miner's cap and connected by wires protected by flexible metallic tubing to a battery which is attached to the waist belt. The design of these lamps indicates that the features of safety and convenience have been very carefully considered.

Heavy Mill Work.—A catalogue of steel and iron castings, shafts, pulleys, toothed wheels, flywheels, hydraulic cylinders and rams, bearings and housings, and completed units, such as speed-reduction gears, has come from Messrs. P. R. Jackson and Co., Limited, Manchester. The firm's products are mainly of the very heavy type, castings up to 30 tons weight, and wheels to 25 tons weight and 30 ft. diameter. Toothed wheels are machine cut or machine moulded. A form of spur tooth now rarely seen but still made by this firm was known as the "G" tooth, and is useful where the drive is always in one direction. A gain of about 20 per cent. in tooth strength is obtained by filling out the roots of the teeth on the non-driving flanks, while retaining the correct involute form on the driving flanks.